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Storied Beliefs: Looking at novice elementary teachers' beliefs about teaching and learning mathematics through two different sources

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Storied Beliefs: Looking at novice elementary teachers' beliefs about teaching and learning mathematics through two different sources, math stories and the IMAP survey

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May 2009

Dedication

This dissertation is dedicated to my parents, Edward and Patricia who never gave up on me and supported me through this entire process. I also dedicate this to my nephew Constantino. In the two short years he has been here, Tino has always brought a smile to my face and my heart.

Acknowledgments

I have so many people to acknowledge that I hope not to leave anyone out. First, I'd like to thank my parents. Their support and love throughout this entire process enabled me to see it through to the end.

I would next like to thank the members of my committee. Tony, Patrick, and Walter accepted me as a colleague, not just a student. They were always available to "talk me down from the ledge" and that support was not lost on me. I admire you as professors and feel lucky to have had you as part of this project.

To my co-chairs, Susan and Corey, your infinite patience and support for me cannot be accurately put into words. I would not have completed this process without each of you helping to keep me going and lending support and guidance. I cannot say enough how much you both have meant to me, and I hope to continue working with you as a peer.

To my committee as a whole: doctoral candidates tell horror stories about their committees holding them up or putting them through agony just because they were subjected to it by their committees. Know that I will never add to those stories. I could not have asked for a more understanding and comforting committee than the five or you. All of you have made me the teacher I am today, and for that I will be eternally grateful.

To my friends at Texas who went before me—Debbie, Erin, Melanie, David, Li, Jane, and Erica—I am blessed to have had your support and, more so, your friendship. We had a lot of laughs and even some tears, but in the end we made it (somehow) by having each other's backs. You always be in my prayers and in my heart.

For my students at Texas, I thank you for allowing me to develop my teaching ability and letting me "experiment" with new ideas to old problems. I enjoyed every second I was teaching you. Hopefully, I was able to bring you something positive.

My UTeach interns—Kara, Casey, Wendy, Jamie, Lisa, and Nick—thank you for working with me in Functions and Modeling and for helping me realize that I was in the right place and doing the right thing by completing my program so that I could help even more children succeed in mathematics. The time we spent discussing the course, fleshing out ideas, and writing our manual was invaluable to me in my pursuing my goal of becoming a better teacher of mathematics.

To my friends and colleagues at Radford University who showed a great desire to have me complete my work and gave me all the encouragement I could ask, I thank you from the bottom of my heart. Special thanks to Pat Shoemaker and Sandy Moore for believing in me and allowing me the time necessary to accomplish this task.

Finally, to Jenn, Tricia, Carmel, Glenna, Bob, Ann Mary, Wendy, Mary, and Laura: a huge thank-you for being my friends from the time I arrived at Radford and cheering me on when it was needed. All your offers of help and support meant so much to me, and, in the end, helped push to over that hump. I couldn't have done it without you.

This research was supported in part by National Science Foundation grant #0138877; Dr. Susan B. Empson, principal investigator. The views expressed here are the responsibility of the author, not the funding agency.

Storied Beliefs: Looking at novice elementary teachers' beliefs about teaching and learning mathematics through two different sources

Publication No._____________

Kevin Daniel LoPresto, PhD

The University of Texas at Austin, 2009

Supervisors: Susan B. Empson and Corey Drake

This study examined the relationship between beliefs found using the Integrated Mathematics and Pedagogy (IMAP) project beliefs survey and the beliefs found in math stories of eight novice (less than two years teaching) elementary school teachers. The stories were coded for the same beliefs used in the IMAP survey. As in the IMAP survey, the strength of evidence of the belief was assigned numerical values, zero through three, indicating virtually no evidence to very strong evidence respectively. Results showed that specific beliefs could be found in math stories, yet not always at the same level of strength as the IMAP survey. This indicates that each conveys differing views on the teachers' beliefs, and thus provides more detailed pictures of the teachers' beliefs. The details include a sense of the trajectory of development of teachers' beliefs from student to teacher that the IMAP survey does not. The math stories also provide evidence of the role of emotion in the formation and entrenchment of beliefs.

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Chapter 1: Rationale

My Journey Begins

I had two goals when I returned to graduate school to attain my Ph.D. I wanted to become a better mathematics teacher and I wanted to pass that knowledge on to future mathematics teachers. I had taught mathematics in grades 7–12 for eight years, and, despite my success, I felt I could do a better job but was not sure how. During graduate school, I achieved my goal of becoming a better teacher. I began to understand how my teaching style, which was very traditional, very “drill and kill,” was not the most effective method. I learned that children have the ability to solve problems on their own and can arrive at their own solutions, which is one of the main tenets of the current reform in mathematics education (NCTM, 2000). Now I needed a way to tackle my second goal: passing on what I had learned to prospective teachers.

The opportunity to instruct prospective teachers presented itself quickly. During my second year of graduate school, I was asked to teach two sections of elementary mathematics methods. Since I had never taught elementary school, I had trepidations, but I took the opportunity. What I experienced was both frustrating and wondrous. The frustration I felt was a result of class discussions I had on the first day. Many students confessed to a fear or even a hatred of mathematics. My frustration, however, was not directed at my students but at the dilemma of trying to teach a topic that many students despised. I did not want to add to their negativity, and I was not sure how receptive they would be.

I quickly realized I was going to have to deal with the students’ concerns directly for them to truly understand what it means to focus on what the *children* know about mathematics rather than on what *they* know. At the time, this realization was based on logic and instinct. I never considered the role that emotion, or even beliefs, played in my students' dislike for mathematics. It seemed logical that if people dislike something, they are less likely to want to learn more about it.

As I reflect on this experience, I understand that what I attributed to instinct was my tacit understanding of the connection between emotions and beliefs. Throughout the semester, during class discussions and using the assigned readings, I asked my students to reflect on their own experiences as mathematics students. I could feel the class's mood lightening throughout the semester. Students started to feel more confident doing mathematics, and that confidence appeared to foster the belief that they could teach mathematics successfully. I must have done a good job because my end-of-course evaluations were excellent. All the students in one of my sections gave me the highest possible score on the evaluation! I felt that I had achieved my second goal.

However, the next semester's class was a different story. While I had some success, it was not very satisfying. I did not have the same feeling of accomplishment that I had the previous semester. At the time, I attributed it to different group dynamics. Since these new students did not like mathematics, as with the first semester's students, I addressed the problem in the same manner as before. My thinking was that it had worked once, so it should work again. It did not.

Some students still insisted that since a more traditional method worked for them, it would work for their students. I was surprised that those beliefs were still held after all the reflections I had them do. It was not until I took a psychology class on emotions that I realized their beliefs and emotions about mathematics played a huge role in how they viewed themselves as mathematics teachers. I had not accounted for that influence when I taught the second group of students. I began looking for literature that examined teacher beliefs and their influence on pre-service teachers. The more I read, the more I knew that I wanted to explore this issue further.

The First Choice is Not Always the Best Choice

I initially wanted to research teachers' perceptions of self-efficacy—their beliefs that they would be successful teaching mathematics. But no faculty members in my department were doing research in this area. My advisor at the time was very willing to work with me on it, but he did not know the field very well.

I continued to read more on the topic, but it was apparent that studying this topic would be challenging. The most difficult challenge was finding a way to measure teachers' self-efficacy in mathematics. I found many measures, but they were either too general or specific to content areas other than mathematics. I concluded that I would need to create my own measure—a difficult task considering that I was not working with anyone who knew the field well. As I reflect on this process, it is possible that math stories could aid in measuring teachers' efficacy. Perhaps when examining the "tone", positive or negative, feel of the story could aid in examining teacher efficacy.

In addition, I began to realize that self-efficacy, although important, was not what I wanted to study. I wanted to find a way to explore beliefs as well as the experiences that could lead to the formation of the beliefs. Self-efficacy measures did not investigate past experiences in sufficient detail. I remained steadfast in my goal to study the role of teacher beliefs as they related to mathematics. At this point, I was not sure whose beliefs I wanted to study. I knew it would not be beliefs about a specific mathematics course (e.g., algebra). I wanted to look at overall beliefs about mathematics and mathematics teaching. The key question was: What could I add to the existing body of research on the topic?

That question was answered about a year later when I was introduced to the concept of “math stories” (Drake, Spillane, & Hufferd-Ackles, 2001; McAdams, 1993). These stories are teachers’ recollections or perceptions of various events in their lives as they relate to mathematics. I liked the idea of the math story because it described not only what happened (at least from the narrator’s perspective), but also how the teller of the story felt. It elicited specific types of information by focusing on key events, but it left room for the respondent to go in any direction he or she desired.

The Use of Narrative

Before continuing with this story, I would like to explain my use of narrative as the format for this chapter. First, narrative is an effective vehicle for detailing exactly why I wanted to do this study. Second, I want to illustrate how a story, particularly a first-person narrative, can be a powerful tool for conveying information (Bruner, 1994; McAdams, 1993). My own story highlights the thought processes I went through while narrowing down my topic. My interest in studying two different sources of information about teachers’ beliefs stems from my role as a teacher educator. I know beliefs play a role in the decisions teachers make, and I want to know as much as I can about them. Identifying specific beliefs in math stories is a gap in the existing literature on the topic. Thus, showing specific beliefs found in math stories is significant in its own right.

I will continue to employ a narrative format throughout this chapter as well as other chapters, where appropriate. This approach underscores one of the main themes of the study – namely, that stories are powerful tools to convey information within the context of one’s life. If I did not use a story format, it would be analogous to watching just the end of a baseball game or just finding out the final score. While the result is discovered, there is no context as to how the game was won. Did the pitchers struggle? Did the winning team come from behind? Did the losing team have a rally that simply fell short? The use of narrative also allows you, the reader, to know my thoughts while I was conducting this study.

The Transition to Studying Stories

I arrived at a topic to investigate: the relationship between beliefs and teachers' math stories. While I initially wanted to examine pre-service teachers' beliefs, I ultimately worked with in-service teachers. The teachers were part of an NSF-funded project with which I was associated. They had fewer than two years of teaching experience. The decision to use in-service teachers was logistical. By focusing on novice teachers, I could support them during the project, as well as learn valuable information about them. They would be able to provide me with data about their experiences in the classroom that pre-service teachers could not.

With that decision made, I was ready to begin! I read many articles on teacher beliefs, the use of math stories, and the impact of prior experience on teachers' beliefs and practices. My motivation to learn more about beliefs stems from my role as a teacher educator whose goal is to aid teachers in understanding what it means to teach using a student-centered, teaching-for-understanding approach (Bright & Vacc, 1994; Hart, 2002b). I felt that examining and, in many cases, changing teachers' beliefs would foster changes in their practices. I wanted to discover, specifically, the role the recollections of their prior experiences would play.

Arriving at My Topic

What began as a general idea of examining the relationship between beliefs and math stories evolved into examining the relationship between beliefs found in math stories and beliefs attributed to a teacher from a belief survey. From my research I knew that while beliefs were reflected in teachers' storied experiences (Drake, in press; Drake, et al., 2001; Sherin, Drake, & Wrobbel, under review), specific beliefs and how they manifested had not yet been identified in math stories.

I was curious to see how the beliefs found in teachers' math stories related to the beliefs found in a quality belief survey. I wondered if using these two measures of beliefs together would yield more information about teachers' beliefs than just using one measure. I knew from reading the literature that changing teachers' beliefs was difficult and that the more information one could gather regarding their beliefs, the better chance there was of changing those beliefs (Richardson, 1996; Speer, 2005; Wilson & Cooney, 2002). Many studies used more than one source—including belief surveys, observations of practice, interviews, and autobiographies—to infer teachers' beliefs (e.g. Chapman, 2002; Hart, 2002a; Leder & Forgasz, 2002; Pajares, 1992; Speer, 2005; Wilson & Cooney, 2002). Because of the different ways beliefs present themselves, including prior experience, teacher actions, and positions of authority (Raymond, 1997), one source cannot capture enough relevant information.

The value of multiple measures is in investigating teachers' beliefs in more than one context. This gives multiple lenses and, if positioned properly, will serve to magnify teachers' beliefs. The individual alone has to change his or her beliefs. When he or she is presented with information, he or she has to decide whether to accept it or reject it. All I can do, as a teacher educator, is challenge teachers' existing beliefs and ask them to reflect on those challenges.

The source of beliefs that most interested me was prior experiences with mathematics. The literature acknowledged that prior experiences affect beliefs (Hart, 2002a; Lloyd, 2002; Raymond, 1997). I did not, however, find any literature that addressed teachers' recollection of specific events in their lives and how those recollections corresponded to specific beliefs about teaching and learning mathematics. That is when I realized that looking for beliefs in teachers' math stories and using a sound, reliable belief survey could give more information about beliefs. This became my driving force and motivation for this study.

The balance of this chapter is a rationale from the literature to support my own beliefs and experiences regarding the topic. First, I discuss why studying beliefs is important, focusing on the topic of teacher change. Then, I review the two sources I used for information about beliefs: a belief survey from the Integrated Mathematics and Pedagogy Project (IMAP) and math stories. A brief discussion of why I feel beliefs are evident in math stories follows. This chapter ends with a presentation of my research questions.

WHY STUDY BELIEFS

"To understand teaching from a teacher's perspective we have to understand the beliefs with which they define their work," (Nespor, 1987). This quote represents why I feel studying teacher beliefs is important. Many of the students I have taught in my own methods classes learned mathematics in a very traditional manner. They were taught a skill, asked to practice it a few times, and then were given similar problems to do on their own as classwork or homework. For many of them, this process resulted in a fear, or even a hatred, of mathematics. It also imprinted on them a perception of the correct manner of mathematics instruction. In all too many instances, students did not view themselves as successful with this process, yet they believed that mathematics should be taught this way. Lortie (1975) calls this "apprenticeship of observation."

My role as their teacher is to challenge those traditional beliefs in the hopes that they become replaced, or modified, with a more reform-oriented approach. I want my students to see that there are other, more effective methods of teaching children by focusing instruction on their students' thinking and by working toward students understanding the concept, not just the ability to perform algorithms.

Since beliefs about teaching mathematics are formed when teachers are themselves students, these beliefs are deeply engrained and difficult to change (Kagan, 1992). In order for their beliefs to change, teachers must be given the opportunity to reflect on new information that challenges their current beliefs (Wilson & Cooney, 2002). The problem is in targeting the belief to be changed and deciding what new experiences the individual should have in order for his or her beliefs to come into question (Chapman, 2002). Thus, the more that is known about a teacher's beliefs, the better chance there is in professional development or in pre-service education classes to focus on areas to target for change.

For example, a belief survey is given to a class of pre-service teachers in an elementary mathematics methods class. The survey reveals that most of the class believes that students should learn their multiplication facts by memorizing multiplication tables and should be assessed using timed facts tests. The survey also supports the belief that students need to know their multiplication facts before they can solve problems involving multiplication. What is missing from this result is how the pre-service teachers *feel* about memorizing tables and taking "mad minute" tests.

Emotion also plays a role in the strength of beliefs (Abelson, 1979; Goldin, 2002; McLeod, 1992; Nespor, 1987). The teachers may feel that memorizing tables is the correct way for students to learn multiplication because it is the only strategy they know. What kind of success they had does not factor into the equation. In contrast, reading the pre-service teachers' math story reflections on what they felt when memorizing their multiplication tables allows teacher educators to address the issue of the pre-service teachers' emotions.

The pre-service teachers who were successful with the traditional teaching method may be less inclined to believe that this is *not* the most effective way for students to learn multiplication. Simply reading an article or two would not cause their existing beliefs to come into question. They would rationalize the use of memorization of facts in a way that fits their existing schema (Nisbett & Ross, 1980).

A more intense experience is needed to prompt pre-service teachers to question their beliefs, such as conducting a clinical interview with a child. An interview allows the pre-service teachers to observe children's capabilities firsthand. The direct interaction with the child can cause the existing belief to be called into question and, quite possibly, changed (Ambrose, 2004; Phillipp, Clement, Thanheiser, Schappelle, & Sowder, 2003). The purpose of this example is to show that pre-service teachers with beliefs that are deeply informed by their emotions can change these beliefs with help from a teacher educator who understands the math stories and offers unique opportunities to help initiate change.

WAYS TO MEASURE BELIEFS

This section briefly describes the two measures I used to identify teachers' beliefs. Chapter 2 will present in more detail the research behind these measures and why I believe, when used together, they will yield more information about teachers' beliefs than using either one alone would provide.

IMAP Survey

This survey was developed by and used in the Integrated Mathematics and Pedagogy Project, an NSF-funded project conducted at San Diego State University. This survey is not the standard Likert-scale survey or a questionnaire (Ambrose, Philipp, Chauvot, & Clement, 2003). Rather, it presents respondents with classroom scenarios and asks them how they would react. The survey is intended to measure seven different beliefs in three major categories. The three major categories—nature of mathematics, learning mathematics, and teaching mathematics—are areas commonly accepted as the in the research on beliefs (Raymond, 1997; Wilson & Cooney, 2002). The power of this survey is that instead of having respondents select one of four or five predetermined responses, respondents write their own thoughts about what they would do if presented with the scenario in their own classrooms. This kind of survey gives a glimpse into a teacher's practice even though the teachers' actual practices are not observed.

Chapman (2002) conducted a study to examine the professional growth of four high school mathematics teachers. One of the data sources used to determine the teachers' beliefs was role-playing. Teachers were presented with a scenario and then asked to act out what they would do if they were in their classrooms. The IMAP survey could be thought of as a type of role-playing except that the teachers write what they would do instead of acting it out.

In addition, instead of ambiguous, decontextualized questions, the survey places the respondents in the context of their classrooms, which, as the section above stated, is preferable since beliefs tend to be contextual. However, this survey does not provide much information about the respondents' experiences outside the classroom or about their experiences before becoming a teacher. Only one question on the survey asks for experiences beyond the classroom. So, while the information gathered as a result of this survey has proven informative (Ambrose, 2004; Ambrose, et al., 2003; Chauvot, 2002), more information about teachers' experiences with mathematics can add to the body of knowledge in this area.

Math Stories

"If you want to know me, then you must know my story, for my story defines who I am" (McAdams, 1993). This quote exemplifies the power of stories. Any time I have introduced myself and told people what I do for a living, they invariably start giving me a piece of their story as it relates to mathematics. It is the way people connect their past events to their present selves (Bruner, 1994; McAdams, 1993). This continuity allows one's sense of self to come through. McAdams (1993) calls these storied experiences one's "myth." An individual's myth or sense of self (Bruner, 1994) is a powerful tool when looking at teachers. Teachers' stories are not actually their experiences but their *perceptions* of their experiences. These perceptions are far more useful to researchers because teachers' understanding of their experiences affect the decisions they make in their classroom, rather than the actual experiences (Drake, et al., 2001). The true actions that were performed are just that: actions devoid of context. When one reflects on the actions, then a story begins to develop (Bruner, 1994).

I believe evidence of teachers' beliefs resides within these stories. The math story asks teachers to reflect on specific events in their lives. Its power is that it attends to the part of beliefs that fall into the affective domain. Beliefs are traditionally thought of as being a cognitive construct (Goldin, 2002; McLeod, 1992; Pajares, 1992). However, the role that affect (i.e., emotions) plays in teachers' beliefs is often overlooked (Goldin, 2002; McLeod, 1992). What a teacher believes about a mathematics topic, such as fractions, is largely due to the feelings the teacher has for that topic (Goldin, 2002; Nespor, 1987). If the teacher felt frustration when doing fractions as a student, that emotion is associated with fractions and manifests itself in the teacher's instruction. The math story interview elicits teachers' emotions while recalling the events in their relationship with mathematics. Other belief surveys do not, at least not fundamentally.

Additional support for the idea that beliefs will be found in teachers' math stories is the episodic storage of beliefs (Abelson, 1979; Nespor, 1987). These episodes are not organized in a linear, logical order, but instead by the experience or event (Nespor, 1987). The memory of these episodes colors future experiences (Spiro, 1982). Thus, when a student has a critical event or episode in his education, this episode produces a strong memory that may influence his or her teaching later in life. Math stories can bring memories of those episodes to the forefront, giving teacher educators the chance to examine them and probe further, if necessary, in an effort to get to know their students better. Having the teachers (pre-service or in-service) recall the episodes gives them a chance to reflect on the episodes. Reflection on these episodes and subsequent beliefs is necessary if teachers are to change their practices (Nespor, 1987; Wilson & Cooney, 2002).

A Personal Example

An instance comes to mind to exemplify the effect that experiences can have on a teacher's beliefs. In November 2004 I brought 80 third graders from an inner city school to my campus so that my elementary mathematics methods students could interview them. I felt that my students needed to interact with children solving mathematics problems so they could see that the methods taught in my class actually worked with children. Part of the assignment for my students was to write a reflection on their experience working with the children. A majority of them indicated that this experience made a huge difference in what they thought about teaching mathematics. They commented that what they read in the textbook sounded logical, but to see it enacted was the experience they needed to make it real. The entire experience lasted only 60 minutes, but in that time, many beliefs started to change.

RESEARCH QUESTIONS

If teachers' beliefs are to be examined and possibly changed, it is important to know as much as possible about their beliefs. The methods of gathering evidence of beliefs should derive from different points of view. The IMAP survey puts the respondents and their beliefs in the context of their teaching practice experiences, while math stories put the respondents and their beliefs in the context of their experiences with mathematics throughout their lives. In order to determine if this combination is a viable way of looking at beliefs, I considered many germane questions. I determined that the three following questions needed to be answered before others could be addressed:

1. What kinds of specific beliefs can be identified in one's math story?
2. What is the relationship between beliefs found in a belief survey and beliefs found in one's math story?
3. What does looking at both sources tell us about a teacher's beliefs that examining just one source would not?

Chapter 2: Literature Review

PREQUEL

This chapter is a prequel to the story told in the Chapter 1. The purpose of this part of my story is to illustrate why I became a mathematics teacher, my initial understanding of beliefs, and the changes that I have made regarding this understanding. While this may be unusual for a review of literature, I felt it important to understand how the literature affected and aided me in my journey. This study is not just about gathering data and trying to find a different path to take. It is also about my growing understanding regarding the role of beliefs teachers hold and ways to investigate them. While Chapter 1 used a narrative structure to illustrate the impact of narratives, this chapter uses personal beliefs to illustrate the relevance of a review of the literature about personal beliefs.

The Beginning, So to Speak

Education surrounded me for many of my formative years. My mother was an elementary school teacher and my father was a high school English teacher, a vice-principal, and finally, a principal. It certainly appeared that my destiny was in the classroom. It was not until my junior year of high school that I realized I really wanted to be a mathematics teacher. The teacher part was expected, but the mathematics was a bit of a surprise. Neither of my parents, nor anyone else in my immediate family, was very proficient in mathematics. But, for whatever reason, I had an affinity for numbers and a knack for explaining how to "play around" with numbers. I began tutoring my sophomore year in high school, and from that experience I knew teaching was the occupation for me. I had the opportunity to teach a pre-calculus lesson while I was a senior in high school. I asked the teacher of the course if I could and, knowing of my intent to become a mathematics teacher, she allowed me. The experience was amazing! I discovered that the choice I was making was the right one. Looking back on that and other experiences, I can see how my image of teaching mathematics began to take shape. At the time I was not aware of how my experiences were shaping my beliefs and, ultimately, my teaching practice, but now the connections are clear. As I taught I began to notice how my students' past experiences affected their views of math. I taught mostly ninth grade, so my students had eight years of prior schooling and exposure to mathematics. When it became time to arrive at a research topic, these experiences allowed me to take the journey described in Chapter 1. Discovering that the literature supported the role of experience and beliefs in teaching was reassuring (e.g.Cooney, Shealy, & Arvold, 1998; Nespor, 1987; Pajares, 1992; Richardson, 1996; Thompson, 1992). The literature indicated to me that I was pursuing a worthwhile investigation.

ORGANIZATION OF THIS CHAPTER

This literature review consists of several sections. First, I provide a definition for the term *experience.* Second, I provide a timeline for the return to prominence of the study of beliefs as they relate to mathematics education. Next, I present a thorough discussion of the definitions of beliefs, which comprises the bulk of my review. Within the discussion, I examine the difficulty in finding consensus within the literature about what beliefs are. A comparison of beliefs and knowledge helps illustrate the characteristics of beliefs that are important for my own study. The fourth section of the literature review is a discussion of how beliefs are structured within individuals. The final section of the review discusses the IMAP survey and math stories as they relate to measuring beliefs.

WHAT IS MEANT BY "EXPERIENCE"

Conle, Li, and Tan (2002) state, "A student teacher describing physical or mental events from his or her practice cannot offer 'the truth' about them, no matter how truthful the account, but instead offers a narration about experiences" (p. 433). The implication is that when people recount their experiences, they are not talking about the actual events, but their interpretation of the events. Therefore, when I discuss how teachers' experiences have influenced their beliefs, I am referring to the teachers' perceptions or interpretations of their experiences, not the actual events that took place. It would be a methodological impossibility to capture all of the events of one's life. Articles written regarding the use of these perceptions have just used the word "experiences," possibly assuming that the readers would understand that the term refers to perceptions, feelings, and emotions and not to the actual experiences. Even if teachers recount events that have recently happened, it is still their perception of these events that is being recorded. This distinction is important because the use of prior experiences is instrumental to my study. When I use the word "experience" or when I discuss studies that refer to teachers' experiences, I am referring to the perceptions or "narration" (Conle, et al., (2002) of the teachers' lives.

TIMELINE FOR THE STUDY OF BELIEFS

According to Thompson (1992), in the early 1900s, beliefs were studied in conjunction with people's actions. This lasted until the 1930s when new theories focused on observable behaviors rather than beliefs. The shift occurred because beliefs are very difficult to measure (Pajares, 1992). Associationism and, later, behaviorism were the theories of the time. Around the 1950s, cognitive theory began to grow, and beliefs once again had a home in psychological research. By 1980 scholars in many fields, such as anthropology, political science, and psychology, as well as education, were studying beliefs. This resurrection of research on teacher beliefs resulted from a "shift in paradigms" away from process–product studies to studies of the decisions teachers make and the thinking behind those decisions (Thompson, 1992). The researchers were working from the premise that "to understand teaching from teachers' perspectives we have to understand the beliefs with which they define their work" (Nespor, 1987, p. 323).

DEFINING BELIEFS

The term *belief* has been defined as "a simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase 'I believe that . . .' " (Rokeach, 1968, p. 133). The last part of this definition—"capable of being preceded by the phrase 'I believe that . . .' "—appears similar to the notion "I will know it when I see it." I first encountered Rokeach's quote when reading a synthesis of literature about beliefs in mathematics education (Thompson, 1992). I remember thinking, "Is that it? This Rokeach guy must have a pretty simple idea of beliefs." When I read his book where the definition appears, I realized the phrase only conveys a small portion of his definition of beliefs. The definition in its entirety implies that beliefs have the following characteristics:

1. beliefs are about something,
2. the holders of beliefs may be unaware of their beliefs,
3. beliefs are inferred, and
4. beliefs influence the decisions people make.

Understanding these additional characteristics, I concluded that the two lines often attributed to Rokeach's definition of belief serve only to give anyone who reads it some idea of what a belief is. It allows readers a chance to reflect on possible endings to the prompt and to decide for themselves whether they believe something to be true or they know it to be true.

For research purposes, however, a more rigorous definition is warranted (Torner, 2002). Much literature discusses the difficulty of arriving at a rigorous definition of beliefs with which all fields of study can agree (e.g. Abelson, 1979; Cooney, 1985; Eisenhart, Shrum, Harding, & Cuthbert, 1988; Ernest, 1988; Furinghetti & Pehkonen, 2002; Nespor, 1987; Pajares, 1992; Torner, 2002; Wilson & Cooney, 2002). I typed in the search phrase "definition beliefs" into Google Scholar, constrained the time frame from 1970 to the present and searched articles only in social sciences, art, and humanities. The search resulted in 68,500 hits! One would think from all the work done on finding an acceptable, consistent definition that the research community is close to accomplishing its goal. However, one the few consistencies I found in the literature is the lack of consistency with regards to the definition of beliefs.

Upon further reflection on the literature, I discerned two different, but related, discussions. One discussion centered on why it is difficult to obtain a consistent definition based on the abstract nature of beliefs (e.g. Eisenhart, et al., 1988; Leder & Forgasz, 2002; Pajares, 1992; Thompson, 1992; Torner, 2002). The second discussion revolved around recognizing when consensus had been reached (e.g. Furinghetti & Pehkonen, 2002; Goldin, 2002; McLeod & McLeod, 2002). The first issue mainly deals with measuring beliefs. Because beliefs are abstract, they are difficult to measure (Leder

& Forgasz, 2002; Pajares, 1992). Rokeach's definition says beliefs are *inferred,* which implies not being able to directly measure. The issue of measuring beliefs will be addressed later in this chapter as well as in subsequent chapters.

The second discussion arises from my own curiosity regarding the question, "Will we (the research community) know when consensus is reached on a definition of beliefs?" After reading article after article on various definitions of beliefs, I realized that there is some consistency; however, the ways in which the definitions are used or portrayed make it difficult to be sure. After a short review of the literature regarding the question, I share my discomfort and how the literature has helped ease the discomfort.

1. Different *kinds* of definitions are used for beliefs, depending on the audience (McLeod & McLeod, 2002).
2. Various fields have created their own definitions to suit their needs (Furinghetti & Pehkonen, 2002; Torner, 2002).
    a. As a result, many terms have been used in place of beliefs (e.g., values, attitudes) (e.g. Furinghetti & Pehkonen, 2002; Pajares, 1992; Thompson, 1992).

One thing I have discovered while reading this literature is that Pajares (1992) was not understating the situation when he described beliefs as a "messy construct."

Different Types of Definitions

McLeod and McLeod (2002) describe different types of definitions that are used in the literature. The type depends on the intended audience. The authors outline three types of definitions found in the literature:

1. Informal
2. Formal
3. Extended

I will briefly describe the three different types of definitions and provide examples of each.

Informal Definitions

An informal definition is simple and intended for a general audience. Examples of informal definitions are “beliefs are subjective knowledge” (Furinghetti & Pehkonen, 2002), “belief systems are one’s mathematical world view” (Schoenfeld, 1992), and “beliefs are statements that can be preceded by the phrase ‘I believe that…’” (Rokeach, 1968; Thompson, 1992). These definitions provide the audience with an idea of what the concept of beliefs is (McLeod & McLeod, 2002), but they do not provide specific characteristics for the purpose of deepening the understanding of beliefs.

Formal Definitions

A formal definition is for audiences that have more knowledge than the general population of the terms used, but it is still broad. The definition is useful for research in various areas, not just the area that provided the definition (e.g., a definition given by cultural anthropologists could also be utilized by mathematics educators). Goldin (2002) provides a formal definition of beliefs as “multiply-encoded, internal, cognitive/affective configurations, to which the holder attributes some kind of truth value” (McLeod & McLeod, 2002). In the case of a formal definition, who or what determines if the definition is understandable or too complex? A general audience most likely would not understand Goldin’s definition, thus, it is considered a formal definition.

As a mental experiment for myself, I attempted to discern whether Rokeach's definition is formal or informal. I applied the criteria for both conditions. It seems that his definition is worded simply enough that the general public would have an idea as to what Rokeach is defining. Therefore, in that respect, it is an informal definition. However, it is doubtful the public in general would be able to dissect the definition into the components noted earlier in this section; thus, it is classified as formal. Of course, my understanding of the literature on beliefs and education could be coloring my opinion (Spiro, 1982) that the definition is simple enough for the layperson to understand. The big question when comparing informal and formal definitions is: what determines a definition's simplicity, or is it "in the eye of the beholder?"

Extended Definitions

Finally, an extended definition is a formal definition that is enhanced using technical language from a specific field of study. This type of definition is intended for that specific field (McLeod & McLeod, 2002). This distinction in the types of definitions has more to do with syntax than semantics. The wording of the definition may mask its true meaning especially when using an informal definition, as it is less detailed than the others and, thus, key terms may be omitted so the most people understand the meaning.

Relativistic Definitions and Synonymous Terminology

The next reason for the difficulty to come to consensus about the definition of beliefs is somewhat unsettling. Various definitions have been created based on the needs of particular academic fields. This relativistic use of definitions gives me pause. This is likely due to my minor in philosophy and the rationalistic roots it planted. The lack of consensus about what beliefs are has caused various fields of study to define *beliefs* to fit their own needs. For example, anthropologists and educational philosophers use the working definition “a proposition or statement of relation among things accepted as true” (Eisenhart, et al., 1988, p. 53). Within these various fields, terms such as *conceptions*, *ideas*, *theories*, and *attitudes* are synonymous with *beliefs* (Furinghetti & Pehkonen, 2002; McLeod & McLeod, 2002; Pajares, 1992). These synonyms make it difficult to know if the various authors were talking about the same construct.

Attitudes

One term, *attitudes*, is especially problematic in that contradictions appear in the literature as to the relationship between attitudes and beliefs. In some cases, *beliefs* and *attitudes* are used interchangeably (e.g.Martino & Zan, 2001; Pajares, 1992; Thompson, 1992). In others, attitude is a component of belief (e.g. Eisenhart, et al., 1988; Richardson, 1996). An example of this case is: “a belief is a way to describe a relationship between a task, an action, an event, or another person and an attitude of a person toward it” (Eisenhart, et al., 1988, p. 53). Other definitions have beliefs as a component of attitudes The beliefs form the organizational structure of an attitude that centers on a common object (Rokeach, 1968). Still others view beliefs and attitudes as separate components of the affective domain, which, along with emotions, form a continuum within the affective domain. Their placement in the continuum is based on their levels of cognition. Beliefs are at one end (more cognitive), while emotions are the other end (less cognitive) (McLeod, 1992). Despite these varying characterizations of beliefs and attitudes, one element in common is that they do not lie completely within the cognitive domain but occupy space in the affective as well. The role of beliefs in the affective domain is the definition that is not consistent.

Summing up Difficulty in Defining Beliefs

Because of these two reasons—the use of various types of definitions and the creation of a definition to suit a particular field of study—realizing when consensus is reached is difficult. The research community seems to have a desire to reach consensus (e.g.Eisenhart, et al., 1988; Furinghetti & Pehkonen, 2002; Goldin, 2002; Leder & Forgasz, 2002; Martino & Zan, 2001; McLeod & McLeod, 2002; Pajares, 1992; Richardson, 1996; Torner, 2002). A major reason for this desire is that an accepted definition can help set relevant research questions (Torner, 2002). The question then becomes, "How is an 'agreed upon' definition necessary or even possible?" Can all fields of study use the same definition? Should flexibility be allowed in the definition to suit the many needs of the various users of the definition? What characteristics are necessary in order to create a consensual definition? These questions do not have simple answers; however, many feel that flexibility is inevitable when it comes to defining beliefs (e.g. Eisenhart, et al., 1988; Furinghetti & Pehkonen, 2002; McLeod & McLeod, 2002). This means accepting that different types of definitions will be used based on the audience and that the various fields of research would use different extended definitions since an extended definition is one where the terminology is associated with a specific field of study. Thus, a vicious cycle is created of not knowing whether there is consensus or not. It seems more prudent to look at the characteristics that make up beliefs. Perhaps there can be agreement on the characteristics of beliefs, which can then lead to an agreeable definition.

CHARACTERISTICS OF BELIEFS

Characteristics of beliefs can be found in researchers' comparisons of beliefs and knowledge. The distinction between the two constructs is not simple. Frequently, the discussion of beliefs comes down to a discussion of how beliefs are not the same as knowledge (e.g. Eisenhart, et al., 1988; Furinghetti & Pehkonen, 2002; McLeod & McLeod, 2002; Nespor, 1987; Pajares, 1992; Thompson, 1992). Before discussing some of the differences between beliefs and knowledge, it is prudent to return to my own story and tell what my understanding of the distinction is and how it came to be. This sets the context of this discussion and its importance to my study. It also illustrates how my views on the topic have started to change because of reading the literature and reflecting upon it.

The Distinction Between Beliefs and Knowledge

I was a philosophy minor in college, not because I had a driving interest in philosophy, but because I had a taken a few logic courses for my mathematics major. This put me a few classes short of a minor, so I decided, “Why not?” One of the classes I took was an introductory philosophy class in which we discussed, among other things, the views of Plato, Socrates, and Aristotle, as well as the theories of rationalism and empiricism. A large portion of the course was devoted to the definition of knowledge. Within this section of the course, beliefs entered the story.

The discussions in class centered on knowledge, which was defined as “justified, true beliefs.” From this moment, I saw beliefs as a component of knowledge. Discussions about the nature of beliefs were few. The main discussions dealt with what constituted sufficient evidence to indicate that a true belief was actually knowledge. As I reflect back, it appears that the professor assumed everyone in the class knew what he was talking about when he mentioned beliefs. Instead of talking further about the characteristics of beliefs, he just discussed them as they related to knowledge.

One of our discussions centered on why having a belief about something was not the same as having knowledge about something. The explanation was that people could have conflicting beliefs. If beliefs were the same as knowledge, then true, conflicting beliefs would be possible, and contradictions could exist. This would lead to a relativistic notion of knowledge, meaning knowledge would be anything one believes. There would be no, as Plato called them, absolutes (Edgar, 1980). If there were no absolute truths, then there would be no knowledge. This is a skeptic's dream world, but for the rest of us it is chaos. The discussion was very interesting and really made me think about what knowledge is and what constitutes it. I firmly maintained that much of what people claimed as knowledge is, in fact, a strongly held belief.

My understanding of beliefs was simply that they were one component of knowledge. When I started to read the literature, I soon realized that my understanding was woefully narrow and that the distinction between beliefs and knowledge was not as simple as I thought. For example, I never explicitly considered the connection between beliefs and the affective domain (i.e., emotions). My understanding placed beliefs squarely in the cognitive domain. I soon realized there was much more to them. At this point, my story comes full circle, because I am now back where I was in my introductory philosophy class: examining beliefs and knowledge. What follows are characteristics of beliefs that stem from the comparison of beliefs and knowledge.

Beliefs Versus Knowledge

Abelson (1979) listed seven conditions that separate belief systems from knowledge systems. Nespor (1987) further distinguished individual beliefs from belief systems by discussing four of Abelson's conditions as appropriate to differentiate individuals' beliefs from knowledge (Pajares, 1992). These conditions are:

1. Existential Presumption
2. Episodic Storage
3. Alternativity
4. Affective Aspect

Reading about these four characteristics allowed me to broaden my understanding of beliefs and the contributions math stories and a scenario-based belief survey can make in my study. Below, I detail the debates in the literature regarding these issues and explain how each one informed the design and implementation of my study.

Existential Presumption

The first characteristic of beliefs is existential presumption. Abelson defines this characteristic by stating that part of the function of beliefs concerns the existence or nonexistence of conceptual entities such as God, ESP, and conspiracies. Rokeach (1968) calls beliefs with this characteristic "taken for granted" beliefs (Pajares, 1992). Nespor acknowledges Abelson's examples, and states that this "taken-for-granted" characteristic may not present itself overtly. This characteristic manifests itself in the classroom by the labels teachers attach to their students. For example, a teacher whose image of teaching mathematics is to have students memorize and practice their multiplication facts would emphasize seatwork and label students who were not succeeding as "lazy." Another teacher, who feels that students' lack of success is due to not being "developmentally ready" for the particular content, may not change her style of teaching because it will not make a difference. These teachers may not be aware of these beliefs, or if they are, they may feel the beliefs are beyond their control (Abelson, 1979; Nespor, 1987; Pajares, 1992). These beliefs can also play a role in the organization of a belief system (Abelson, 1979). By obtaining teachers' math stories as well as responses to classroom scenarios, researchers can obtain a sense of the images a teacher has about teaching mathematics, where these images may have originated, and how they are influencing the labels, whether implicit or explicit, that teachers place on their students.

Episodic Storage

A second characteristic of beliefs is episodic storage (Abelson, 1979). Abelson, supported by Nespor (1987), contends that the bases for the organization of beliefs are experiences, episodes, or events. These bases are opposed to the basis of knowledge, which tends to be stored in a logical sequence. These episodes influence beliefs. Teachers can point to critical events that have made an impact on their lives, whether the impact is negative or positive.

The recollection of these episodes, however, is not true recollection, but memory filtered through beliefs, or, as Spiro refers to it, "background coloration" (1980). The adjective "background" does not refer to the idea that coloration is secondary or of minimal importance. Instead, it implies that teachers may not be aware that their experiences are coloring their beliefs. Teachers may not even be aware of their beliefs (Kagan, 1992), so it stands to reason that teachers' experiences color or "filter" their beliefs in the "background" of their minds.

Nespor (1987) sums up the episodic nature of beliefs when he says, "it seems more likely that some crucial experience or some particularly influential teacher produces a richly-detailed episodic memory that later serves the student as an inspiration and a template for his or her own teaching practices" (p. 320). This quote suggests not only the importance of individual events in the development of teachers' beliefs, but also how pre-service teachers (unlike other professions) have a rich detailed image of teaching before entering the classroom. Math stories and the IMAP survey consist entirely of episodes—experienced (math stories) or purposely manufactured (IMAP survey). They should be able to capture the episodes and allow researchers to sift through them to infer teachers' beliefs.

Alternativity

The third characteristic of beliefs implies that people's beliefs contain representations or images of "alternate realities" (Abelson, 1979; Nespor, 1987). These realities are often plot lines in science fiction, particularly the *Star Trek* series. In a more mundane sense, this characteristic seems to imply that there is not necessarily a direct causal relation between experiences and beliefs. If people have a negative experience in a setting, then beliefs could be developed that would guide their actions (Cooney, et al., 1998; Pajares, 1992) to avoid the same setting for themselves or others. For teachers, if they were only in classrooms as students where the environments were negative and stifling academically, they could develop a belief system with respect to the environment of their own classroom in that it should be positive and academically free. This could happen even *without* experiencing that kind of classroom environment. Skott (2001) labels these representations school mathematics images (SMI). SMI are interpretations of teachers' experiences and priorities when it comes to mathematics and teaching mathematics. Therefore, while teachers may have had negative experiences as mathematics students, their SMI is of their ideal classroom that spares their students the unpleasant experiences they had. To clarify, these SMI are not teachers' beliefs. However, they can influence beliefs and, in turn, their beliefs can influence the images they create. I have seen evidence of this reciprocity when reading my pre-service teachers' math stories. One of the more frequent lines when they reflect on their negative experiences is "Now I know what not to do." For example, a student who was made to feel incompetent when she did not solve a problem the exact way her teacher did would want to make sure her future students did not feel the same way. Thus, she allows them to solve problems in a way that makes sense to them, not because she necessarily believes they are capable, but because she does not want them to feel the same way she did. The vision of this environment is not based on direct experience, but on the desire to protect her students from the negative emotions she felt. Thus, while she appears to have a strong belief that children should solve problems in their own way, there appears to be a stronger belief, born out of affect rather than cognition (Nespor, 1987), that is more likely the reason behind her willingness to have students use their own methods. It is scenarios similar to this one that will be investigated in Chapter 4.

Abelson (1979) and Nespor (1987) liken this characteristic to humanity's continual search for the ideal. Many people have visions of their perfect house, job, and mate. In relation to this study, the IMAP survey allows the teachers to express what ideally they would do in certain classroom situations. The math story could give indications as to whether the beliefs, evidenced by IMAP, are alternate realities to those experienced by the teachers. The math story can also show the role emotion plays in the teachers' constructions of their ideals. This could then yield information as to the strength of the belief that formed based on their SMI.

Affective Aspect

The final characteristic of beliefs to discuss is the affective aspect. The literature regarding beliefs and affect indicates that emotions and feelings play a role in the strength of beliefs. Though the concept that beliefs lie partly within the affective domain is common in the general literature about beliefs, it has not been prominent in research within mathematics education (Goldin, 2002; McLeod, 1992; McLeod & McLeod, 2002). Goldin (2002) claims this is due to "the popular myth that mathematics is a purely intellectual endeavor in which emotion plays no essential role" (p. 59).

First, I will discuss the role of affect in beliefs in general, and then I will discuss beliefs specifically regarding mathematics teaching and learning. Abelson (1979) writes that knowledge of content is different from the feelings regarding content. Nespor (1987) concurs, stating that values, feelings, moods, and subjective evaluations are independent of the cognition commonly associated with knowledge (Pajares, 1992). The feelings teachers have regarding a particular content play a role in the importance teachers place on the content (Pajares, 1992). For example, if a teacher does not feel that science is important for students to learn well, then that teacher may not work as hard to prepare effective science lessons due to his devaluation of the subject. In contrast, a teacher who feels that his students must learn to write in cursive in order to succeed in life may spend an inordinate amount of time working with students to develop perfect penmanship, possibly to the detriment of other subjects. His high value of cursive dictates the large amount of time he is willing to spend.

Pajares (1992) discusses another view regarding the evaluative nature of beliefs suggested by Nisbett and Ross (1980). Knowledge is broken down into two parts: a cognitive component and a belief component. In this viewpoint, beliefs are regarded as a type of knowledge. The beliefs may surface when working with a particular subgroup of students about which the teacher has preconceived notions. For example, a teacher may believe that females are incapable of taking higher-level mathematics. She says she "knows" that females will not need it in their lives. This teacher's "knowledge" is colored by her values and possibly her feelings regarding higher-level mathematics (Nisbett & Ross, 1980; Pajares, 1992; Spiro, 1982). Thus, her knowledge may not be based on sufficient evidence, but instead on strong emotion. This emotion influences how she views her experiences and the different phenomena she encounters (Pajares, 1992).

When first reading the literature about the affective domain, the inclusion of beliefs within this domain seemed like common sense. The more I thought about it, the more I began to wonder why I did not think of it before. Reflecting on this oversight, I realized that since my understanding of beliefs was based on the role it played in defining knowledge, affect was not an issue. Knowledge was a purely cognitive construct (at least to me), so beliefs were also. Moreover, the idea that judgment or evidence that validates the truth of a belief is based on *any* emotion brings me back to the relativity issues I discussed earlier. I still have this belief (I know it is a belief) in absolutes—knowledge is Knowledge (with the uppercase K signifying the absolute), regardless of who has the knowledge. I find it difficult to accept that knowledge is not Knowledge until someone knows it—that an individual or a group has to label it knowledge for it to be so.

My growing understanding of constructivism as a theory of learning in which individuals construct their own knowledge has allowed me to reconcile, to a point, the distinction between knowledge and Knowledge. Knowledge (uppercase K) is still an absolute, existing outside of time and space. Whereas knowledge (lowercase k) is constructed by an individual or group and is therefore knowledge for that individual or group, it is not necessarily knowledge for anyone else, *yet.*

This new understanding I have reflects a characteristic of belief systems called *non-consensuality* (Abelson, 1979). Non-consensuality means that people who hold certain beliefs accept the fact that others will have systems that oppose theirs. This does not occur in knowledge systems (Abelson, 1979; Nespor, 1987; Pajares, 1992; Thompson, 1992). While this seems misplaced in a section talking about characteristics of individual beliefs, I feel it is better suited here, since it gives credence to my understanding and allows me to feel comfortable with the idea of the different kinds of knowledge I have described above. This attribute fits with my question "Is the system aware that other beliefs are plausible?" If not, then the people (or person) who hold this system of beliefs feel it is Knowledge. To someone outside the system, it can appear to be a belief system since the observer is aware of other beliefs. This speaks to the many uses of the word *know* in common language. Because of my insistence in absolutes, I always cringed when I heard others use "know" regarding something that I did not regard as knowledge. I am just as guilty as anyone of the same *faux pas*. I always considered it an issue of semantics, but I see now it is more than that. The fear I have is replaced by a new understanding that knowledge is not relative. It has a temporal quality based on the theories and information at the time (Thompson, 1992). By fighting this notion, I was keeping myself from seeing this quality of belief systems known as non-consensuality.

It was my earlier understanding of knowledge that blocked me from realizing the role affect plays in beliefs. By reflecting on the *episodes* in my life where I thought about beliefs and knowledge, accepting the *alternative* idea that knowledge can be constructed by individuals or groups, and not eradicating my belief of the *existence* of an absolute Knowledge, I now can accept the role emotions play in the formation of beliefs. I am reassured that the measures I am using can capture them. I will continue the discussion of the role of affect and beliefs by focusing specifically on mathematics education research.

While the conditions of existential presumption, episodic storage, and alternative realities are considered important, the concept that beliefs are part of the affective domain is often overlooked (Goldin, 2002; McLeod, 1992; McLeod & McLeod, 2002). How teachers instruct students in mathematics has a lot to do with the values, feelings, moods, and subjective interpretation of their beliefs. Parallel to that, the emotions students have regarding mathematics also influence their ideas about mathematics. If a teacher or student experiences a pattern of frustration, then that frustration aids in the development of the belief that mathematics is hard. Conversely, if a teacher or student has great success and feels glee concerning mathematics, then mathematics is believed to be easy or fun (Goldin, 2002).

McLeod (1992) points out that teachers often discuss their students' *feelings* regarding mathematics as well as their perceived ability. This only strengthens the case that affect is an integral component of beliefs. McLeod also states that it is socially acceptable to proclaim ineptitude in math. Some wear it as a badge of honor. No matter where I am, when those around me find out I am a math teacher, invariably they launch into a story about how they do not like mathematics or are not very good at it. What individuals say is not so much, "I don't know math" but "I don't like math." They seem to be equating dislike of mathematics with lack of proficiency. If beliefs are going to be changed concerning mathematics, then the affective responses have to be addressed and changed, not only of the students but of the teachers as well (McLeod, 1992).

Goldin (2002) takes McLeod's work further by proclaiming that "affect stabilizes beliefs; beliefs establish meta-affect contexts." Meta-affect is how one feels about a particular feeling. The link between the cognitive and the affective nature of beliefs has been missing from the literature (McLeod & McLeod, 2002). While looking at one's feelings is important, it may not be the whole story. One's emotions may have either a positive or a negative effect on the individual. An example is fear. While most people have a negative feeling about fear, this emotion could also have a positive effect on individuals. An example is the enjoyment of watching a good scary movie. I have always loved monster movies, dating back to when I was a child watching the original Frankenstein, Dracula, and werewolf movies. The movies I like best now are ones that make me jump every now and then. Sometimes, the anticipation of something happening can be more original and exciting than actually witnessing the event. In this case, fear is perceived as a positive emotion; I am disappointed when a scary movie does not live up to its billing. In this instance, not feeling fear is a negative. On the other hand, I can experience fear as a negative emotion, especially when my back is to a doorway or an entryway. I am always fearful that someone will sneak up behind me. A reason for my positive attitude towards fear when watching scary movies may be the fact that I believe that these monsters do not exist in my world and, thus, will not harm me. Therefore, this belief stabilizes the positive meta-affect of fear that I have.

This concept of meta-affect as it applies to mathematics is simple. Many elementary school teachers have a self-professed fear of mathematics (Cooney, 1985; Ernest, 1988; Ma, 1999; Smith III, 1996). This fear may only be in one specific content area such as algebra or geometry, but it colors their view of mathematics in general. While many people view this fear as a negative, others view it as a positive. For example, the fear may result from the anticipation of trying to answer a difficult question in a mathematics competition. The fear of letting the team down or of having to solve an unfamiliar problem can be a motivating factor. It is a positive since it requires complete focus to the task. In my own case, I am always fearful before I teach a class or give a presentation to teachers regarding mathematics education. It is that fear that does not allow me to take teaching for granted and pushes me to prepare solid presentations. Therefore, the fear is a positive; it is motivational. It lets me know that I have to be on top of my game every time I teach.

Frustration is also a popular emotion in teachers when discussing their experiences with mathematics. A common frustration often described in math stories is the feeling that the teacher was not helping them. When children struggled with a certain aspect of mathematics, their teachers often did not appear to provide the necessary help or encouragement. Referring back to the concept of alternativity, when these students become teachers, they establish an environment to ensure that their students do not feel the same frustration. While this may be a positive emotion to the teacher because she is not allowing her students to feel the negative emotion of frustration, it could be a negative for students because the teacher is not allowing them to struggle with their own thinking. It can also be a negative in the long run because the teacher is too quick to provide help, and the students become overly dependent on the teacher and do not develop autonomy.

From the two above examples, it should be clear that meta-affect is context-related. The context can relate to an individual person (scary movies vs. sitting with back to door) or it can relate to groups of people (those proficient in mathematics vs. those who do not feel they are). The contextual nature of meta-affect makes sense because beliefs are context-related and beliefs stabilize meta-affect, thus meta-affect is context-related.

Belief Structures

The previous sections discussed the characteristics of individual beliefs. The next logical step is to discuss the organization of these beliefs within an individual. Rokeach (1968) asserts these systems are organized in some "psychological but not necessarily logical form" (p. 2). Green's work on belief structures takes this assertion and provides three dimensions of belief systems (1971). These dimensions have stood the test of time, and his work is prominent in the literature on beliefs (e.g.Ambrose, et al., 2003; Cooney, et al., 1998; Thompson, 1992; Wilson & Cooney, 2002). The three dimensions of belief structures Green (1971) provides are:

1. Quasi-logical relation between beliefs
    a. Primary

    b. Derivative

2. Psychological strength

    a. Central

    b. Peripheral

3. Beliefs are held in clusters

Next, I will elaborate on these dimensions and show how to apply them to teaching mathematics.

Quasi-logical Relation Between Beliefs

The term *quasi–logical* refers to the idea that while the entire system may not have a logical structure, it has one locally. Initial or *primary* beliefs lead to subsequent or *derivative* beliefs. A result of this local logical characteristic is that no belief is independent. A link exists to at least one other belief (Cooney, et al., 1998; Green, 1971; Thompson, 1992). This relationship is analogous to the relationship of mathematical theorems (primary) and their corollaries (derivative). This distinction allows for the idea that belief systems are locally dynamic. As individuals experience life, they develop additional derivative beliefs from their existing primary beliefs. A caveat is that whether a belief is primary or derivative does not indicate how strongly held the belief is.

An implication of the quasi-logical organization of the structure of beliefs is that it is unbounded (Abelson, 1979; Nespor, 1987; Pajares, 1992). This characteristic acknowledges a core set of beliefs (primary) and that beliefs can branch off this core set in unexpected ways. This is evidenced when people use “very agile mental gymnastics” to hold on to their beliefs even if evidence is presented to contradict them (Nisbett &

Ross, 1980). Emotion usually plays an integral role in these gymnastics, further underscoring the importance of affect in belief systems.

Psychological Strength

Psychological strength is the main distinction Rokeach (1968) uses to explain how beliefs align. The discussion about strength of conviction takes place in this dimension. That is, the stronger held the belief, the more influence it has on the system, and, thus, the more difficult it is to change. At the heart of the system lie central beliefs. These beliefs are the strongest of the system and resist change. These beliefs perform the gymnastics mentioned in the above section. These central beliefs are difficult to change and will adapt any contrary information so that it aligns with the beliefs (Nisbett & Ross, 1980). On the outskirts of the system lie peripheral beliefs that are weaker and, thus, easier to change.

Before moving on to the relation between psychological and quasi-logical belief structures, let's return to the alternativity characteristic. This characteristic of beliefs implies that people can hold beliefs based on images of their ideal situation, even if they never experienced it. These beliefs have a strong affective component, and thus are imbedded deeply within a belief system. These deeply embedded beliefs can be central to a system, even though they are based on alternate, rather than real, experiences. This could be problematic when measuring beliefs based on experiences, because the respondent did not actually have the experience.

The relation between the psychological strength and the quasi-logical belief structures is not a direct one. That is, primary beliefs are not necessarily central and derivative beliefs are not necessarily peripheral (Thompson, 1992). For example, a teacher believes that students should be allowed to use technology in mathematics class (primary belief). This belief, however, may not be very strong (peripheral) so that when the use of technology is not readily available, his willingness to use it may wane (Cooney, et al., 1998). Thus, the primary belief for using technology is a peripheral belief in his system.

Clusters

The third dimension of systems is that beliefs occur in clusters. These clusters are systems in and of themselves, and they exist independently of each other (Cooney, et al., 1998; Thompson, 1992). The independent nature of the clusters differs from the primary–derivative relation. Both imply that beliefs are connected in some way; the primary–derivative relation is a causal relation. The derivative belief is born from the primary belief. In contrast, clusters are subsystems of a larger system. Beliefs in the clusters have quasi-logical relations, as well as varied psychological strength. The clusters tend to be context-specific, meaning a teacher may have clusters of beliefs for teaching mathematics and entirely different clusters for teaching reading. The clusters help to explain why it may appear that a teacher holds contradictory or inconsistent beliefs between different content areas (e.g., mathematics, reading, science) (Cooney, et al., 1998; Green, 1971; Thompson, 1992).

To illustrate, imagine an elementary school teacher who teaches writing in a student-centered manner. The children in her class write about topics that interest them. Spelling words are not pre-determined but evolve from the students' writings. They deal with issues of grammar and sentence structure in the course of the peer review process that the teacher has implemented. The teacher acts as a guide for the students, not the deliverer of information. On the other hand, this same teacher uses a teacher-centered approach to teaching mathematics. She does not allow her students to work on problems that interest them. The facts the children need to know are pre-determined and are not part of a problem-solving process. Little peer review occurs, other than asking the class if someone is correct or not. The teacher is the sole source of information (Spillane, 2000).

To the outside observer, it appears that the teacher has conflicting beliefs, but she does not see it this way because her belief clusters about teaching mathematics and writing are separate from each other in her beliefs system. This situation highlights the content dependency of the clusters (Cooney, et al., 1998; Green, 1971). The content influences the strength of the teacher's beliefs. Since my study is focused on mathematics, my interest is in discovering, as much as possible, the central beliefs of the cluster regarding teaching mathematics in general.

This presents a problem, however, since central beliefs are stronger within the system and, thus, work tacitly or subconsciously within the system. The holder of these beliefs may not be aware of the beliefs (Pajares, 1992; Rokeach, 1968). More likely, the beliefs that are measured are peripheral beliefs (Green, 1971; Pajares, 1992; Thompson, 1992). If so, then it would be easier, if not prudent, to try and trace these peripheral beliefs back to some central belief. A logical assumption is that these peripheral beliefs are also derivative of some primary beliefs. As mentioned above, the relationship between psychological strength and the quasi-logical relation is not direct; however, this does not mean that it is not possible. Since I am assuming the beliefs for teaching mathematics in general reside in the same cluster, and that the beliefs are connected in some way, it is reasonable to assume that central, primary beliefs yield peripheral beliefs and that these beliefs that can be measured.

Measuring Beliefs

The measures used should investigate beliefs within the context to be studied (Pajares, 1992; Speer, 2005). For example, Speer (2005) claims that if one wants to research the way beliefs shape a teacher's practice, then data must be collected "in conjunction with data on the practices that one seeks to understand" (p. 370). Thus, if one wants to research the effect that teachers' experiences have on their beliefs about teaching and learning mathematics, then data need to be collected within the context of the teachers' lives, as well as their practices. Different measures are useful for different aspects of investigating teachers' systems of beliefs (Leder & Forgasz, 2002).

Some of the most widely used measures are questionnaires in which respondents indicate their level of agreement with a statement on a Likert scale (Leder & Forgasz, 2002). While easy to score, these surveys can yield ambiguous answers (Ambrose, et al., 2003; Leder & Forgasz, 2002). One of the drawbacks of the Likert scale measures concerns the idea of "shared understanding" (Ambrose, et al., 2003; Speer, 2005). The respondent may have different interpretations of key terminology such as problem solving and the use of manipulatives. This could lead to the erroneous conclusions on the part of the researcher regarding inconsistencies between teachers' practice and their professed beliefs. A teacher could say that she agrees with the notion that students need to be independent problem solvers, and yet when observed, she instructs the children on how to solve certain problems and then allows them time to practice solving them on their own. To her, the method she is using is "independent problem solving," since the children do some work on their own without the teacher showing them how to solve the problem. To a researcher versed in the problem-solving based instruction, that is not what independent problem solving is supposed to look like. The researcher attributes it to inconsistency, while the teacher is wholly consistent between her beliefs and practice. More detailed, contextual-based measures make sure both teacher and researcher are speaking the same language (Speer, 2005) .

Another drawback is that complex situations allow a better inference of teachers' beliefs (Pajares, 1992; Rokeach, 1968), and Likert scales often do not provide these kinds of situations (Ambrose, et al., 2003). Since many of the items on Likert scales are generalized, it is difficult to know if the respondent is thinking of first grade or seventh grade when answering. The measure should be as specific as possible concerning level of content.

A third drawback is that Likert scales do not measure the importance of an item to the respondent. Respondents frequently answer items because they feel they have to, not because they have a strong feeling one way or another (Ambrose, et al., 2003). To illustrate, I draw on a political analogy. Suppose a poll was conducted asking Americans if they favor making English the national language. Further, suppose 75% of the respondents said they would favor making English our national language. If this was the only question asked in the poll, politicians may take it as a sign that this is a hot-button topic worthy of building a platform around. However, another poll was conducted on the same topic, but this time if the respondent answered that he or she would favor this action, the next question was, “How strongly do you feel about this issue?” or “Would this issue cause you to vote or not vote for a particular candidate?” The results of this second question yielded that, of the 75% of respondents who said yes, only 20% said it was an important enough issue to base their vote on, meaning most of the respondents do not feel strongly about this topic. The authors claim this point is missing in many Likert scale surveys and that the importance or relevance of issues to teachers needs to be taken into account.

IMAP SURVEY

Ambrose et al. claim that the IMAP survey addresses the above issues by attending to four characteristics of beliefs (2003):

1. Beliefs influence perception (Pajares, 1992; Rokeach, 1968). They act as a filter that allows the respondent to sift through a situation and make sense of

it. Thus, the survey asks the respondents to envision classroom situations and allows them to state their hypothetical actions in their own words.

2. Beliefs are not static entities (Abelson, 1979; Pajares, 1992; Rokeach, 1968). They can be held on many different levels (Green, 1971). The tasks in this survey allow varied interpretations, which do not direct the respondent in a particular direction. Thus, different levels of conviction will be evident.
3. Beliefs are context-specific (Cooney, et al., 1998; Eisenhart, et al., 1988; Speer, 2005). This survey supplies contexts to which the respondents can reply.
4. The bi-conditional relationship between beliefs and actions (Cooney, et al., 1998; Eisenhart, et al., 1988; Hart, 2002a; Speer, 2005). This survey supplies answers to the question “what would you do in this situation?” thus giving insight into teachers’ actions in the classroom, which, in turn, can give insight into teachers’ beliefs.

The fourth characteristic given by the authors of the IMAP survey has an interesting implication. It appears that they are claiming that their survey is an indirect method of gaining information on teachers’ practice. Some researchers insist that investigation into teachers’ beliefs has to start by observing their practice (Hart, 2002a; Speer, 2005). This may not always be practical, especially if one is investigating beliefs of pre-service teachers who have yet to enter a classroom. This survey provides a vicarious method of looking at practices of teachers. The use of vicarious methods is not unusual practice. In contrast, videotapes of children solving problems have been used to investigate pre-service teachers' understanding of children's problem-solving strategies (Chauvot, 2002; Philipp, Clement, Thanheiser, Schappelle, & Sowder, 2003).

Furthermore, in professional development, the participants watch video of other teachers and then reflect on their own practices (Bright & Vacc, 1994). Teachers may also watch video of themselves and then reflect on what they saw (Hart, 2002a; Junk, 2005; Speer, 2005). Since the data comes from the reflections of the teachers and not directly from the observation of the teacher, it can be viewed as an indirect method of collecting data. This survey allows the same opportunity to observe teachers' practice and gather their reflections. The difference is that the teachers are not physically teaching but responding to scenarios. As stated earlier in this chapter, beliefs are stored as episodes, so in providing certain episodes, there is a high probability that some of the teachers' beliefs will surface.

MATH STORIES

The second measure used to collect the teachers' math stories is adapted from a protocol used by McAdams (1993) (Drake, in press; Drake, et al., 2001). One of the key attributes of the math story interview protocol, like the IMAP survey, is that math stories allow the respondents to describe their experiences with mathematics in a semi-structured manner, in that they are asked to reflect on specific events, but their responses are their own. Math stories differ from the IMAP survey in that the scope of the math story is not restricted to teaching. The protocol also allows the interviewer to explore various experiences that come up in the course of teacher's story. The IMAP survey is a web-based survey; therefore, the teacher's responses on it cannot be explored further, at least not at the time the teacher is taking the survey. Therefore, stories can yield different levels of information.

Stories have been a main form of communication as far back as anyone can remember. They give insight into one's sense of self and come complete with plot, settings, and characters (Bruner, 1994; McAdams, 1993). The structure of the stories may aid in making sense of the unknown structure of the belief systems. They can provide paths to pursue in the system. Stories serve as a lens through which teachers can view both their professional and personal lives (Drake et al., 2001). Stories also allow researchers to understand an individual's beliefs in the context of the respondent's life and not as "isolated fragments" (Drake et al., 2001). Drake et al (2001) cite Pajares (1994) by saying, "this systematic understanding of beliefs, as opposed to the fragmentary understanding, is a more accurate representation of the way in which individuals construct, maintain, evaluate and change their beliefs." In other words, math stories may give evidence about the origins of beliefs (Sherin, et al., under review).

Chapter 3: Methodology

I was a member of an NSF-funded research project working with 16 elementary school teachers. Of those 16 teachers, eight had two or fewer years of teaching experience. The project members decided that I could use data from those eight teachers for my study. I was slightly disappointed that I would not be using pre-service teachers; however, I realized that my true goal was to investigate the utility of the two different measures for beliefs; the characteristics of the teacher were less important. I could always conduct further research with pre-service teachers at another time.

All 16 of the teachers in the larger study took the IMAP survey, but only the eight teachers in my study were interviewed regarding their math story. The information that follows was collected from only the eight teachers used in this study.

The range of teaching was grades 1 through 6. The teachers were female and their ages were all under 30. Five of the teachers graduated from university elementary teacher preparation programs. Of the remaining three teachers, one had a bachelor’s degree in human development, and the other two teachers were not certified to teach at the time. They were, however, enrolled in a master’s of education program, where they were planning to obtain their K–8 certifications. Only one of the five teachers who participated in a university teacher preparation program had a specialization in mathematics. One of the teachers had a specialization in science, and the other teachers had specializations in reading, writing, or social studies. The sixth-grade teacher was the only teacher who taught all the mathematics classes for her grade level. The following sections describe the two measures, the IMAP survey and the math story interview, used to collect data from these eight teachers. For each measure, there are two sections: a description of the measure and how the measure was coded.

IMAP Survey

The first measure used with the teachers was a beliefs survey developed by the IMAP project at San Diego State University (Ambrose, et al., 2003; Clement, Philipp, & Thanheiser, 2002). This web-based survey measures seven different beliefs by presenting the respondent with classroom situations involving students' problem solving and allowing them to respond, in their own words, to the different scenarios. An example of one of the scenarios is shown in Figure 3.1.

Question 4 (continued)

Here are those two approaches again so that you can refer to them to finish this section.

Lexi	Ariana
$\begin{array}{r} {}^{5}\cancel{6}\,{}^{1}3\;5 \\ -\;4\;8\;2 \\ \hline 1\;5\;3 \end{array}$ Lexi says, "First I subtracted 2 from 5 and got 3. Then I couldn't subtract 8 from 3, so I borrowed. I crossed out the 6, wrote a 5, then put a 1 next to the 3. Now it's 13 minus 8 is 5. And then 5 minus 4 is 1, so my answer is 153."	$\begin{array}{rcl} 635 - 400 & = & 235 \\ 235 - \;\;30 & = & 205 \\ 205 - \;\;50 & = & 155 \\ 155 - \;\;\;\underline{2} & = & 153 \\ 482 & & \end{array}$ Ariana says, "First I subtracted 400 and got 235. Then I subtracted 30 and got 205, and I subtracted 50 more and got 155. I needed to subtract 2 more and ended up with 153."

For the remaining questions, assume that students have been exposed to both approaches.

4.6 Of 10 students, how many do you think would choose Lexi's approach?

☐ of 10 students would choose Lexi's approach.

4.7 If 10 students used Lexi's approach, how many do you think would be successful in solving the problem 700 – 573?

☐ of 10 students would be successful.

Explain your thinking.

4.8 Of 10 students, how many do you think would choose Ariana's approach?

☐ of 10 students would choose Ariana's approach.

4.9 If 10 students used Ariana's approach, how many do you think would be successful in solving the problem 700 – 573?

☐ of 10 students would be successful.

Explain your thinking.

4.4 Describe how **Lexi** would solve this item: 700 – 573.

4.5 Describe how Ariana would solve this item: 700 – 573.

Figure 3.1: Sample IMAP Scenario

In this scenario the respondent compare two strategies for subtracting three-digit numbers. Lexi's approach is very traditional, while Ariana's uses place-value concepts to subtract from left to right. This type of scenario is one that the respondents could face in their classrooms if they allow children to use their own strategies to solve problems. The question asks the respondent a variety of questions, ranging from "Which child has greater mathematical understanding?" to "Do you think other students, after being shown both solutions, would use either Lexi's or Ariana's?"

This survey was chosen because it was designed to provide convergent evidence that a respondent holds specific beliefs. In other words, the evidence of a respondent's beliefs is found in multiple responses on the survey. No single survey item by itself implies evidence of beliefs. The evidence converges from the use of different rubrics to score the various responses. The survey was also chosen because it investigates beliefs in the context of practice through simulated practice.

Coding the IMAP Survey

After the surveys were completed, the responses were scored using the rubrics contained in the *IMAP Beliefs* survey manual. Depending on the rubric, the segments received scores from 0 through 2, 3, or 4. The higher the number, the more evidence there was that a respondent has a certain belief. In other words, a score of 0 indicates very weak evidence of the beliefs and a score of 4 indicates very strong evidence. This survey *infers* beliefs; it does not conclusively identify them. Below are the seven beliefs the IMAP survey measured (Ambrose, et al., 2003; Chauvot, 2002; Philipp, et al., 2003).

A. Mathematics, including school mathematics, is a web of interrelated concepts and procedures.
B. One can perform standard algorithms without understanding the underlying concepts.

C. Understanding mathematical concepts is more powerful and more generative than remembering mathematical procedures.
D. If students learn mathematical concepts before they can learn standard algorithms, they are more likely to understand the algorithms when they learn them. If they learn procedures first, they are less likely to learn the concepts.
E. Children can solve problems in novel ways before being taught how to solve such problems. Children in primary grades generally understand more mathematics and have more flexible solution strategies than their teachers, or even their parents, expect.
F. The ways children think about mathematics are generally different from the ways most adults would expect them to think about mathematics. For example, real world contexts, manipulatives, and drawings support children's initial thinking, whereas symbols often do not.
G. During interactions related to the learning of mathematics, the teacher should allow the children to do as much of the thinking as possible.

These seven beliefs are split into three main categories:

1. beliefs about the nature of mathematics (Belief A),
2. beliefs regarding teaching and learning mathematics (Beliefs B through E), and
3. beliefs regarding children doing and learning mathematics (Beliefs F and G).

For the purposes of validity, each belief is measured by looking at two or three items on the survey (Ambrose, et al., 2003; Phillipp, et al., 2003). For example, item 5 is used to aid in measuring Belief 5 with one rubric and then Belief 7 using another rubric. In each case, the scorer is looking for something different when using the different rubrics. Figure 3.2 is the scoring sheet for Belief 5 segment 5 (B5-S5) and Belief 7 segment 5 (B7-S5).

B5–S

Scoring Summary

Score	Rubric details
0	Children will not know what to do with the problem OR children's initial work will be incorrect OR both.
1	Children will be asked to solve problems without being shown how to solve them; (a) but doubt in children's ability to solve problems is expressed. (b) doing so will stimulate thinking (but no mention that solution strategies will emerge). (c) but only a very few children will be able to solve the problems. (d) children will generate their own approaches but will do so rarely.
2	Children can solve problems for themselves and will definitely devise solution strategies—but not so reliably as to be the focus of instruction (i.e., one cannot depend on children's thinking as a basis for instruction).
3	Building on children's thinking will be an integral part of instruction (i.e., one can depend on children's thinking as a basis for instruction).

B7–S5

Scoring Summary

Score	Rubric details
0	Don't let students think on their own.
1	**A.** Provide students with a little instruction first and then let them think. **B.** Let students think on their own then tell them "my way." May include a good reason for having children solve problems on own. **C.** Let students think on own so teacher can assess understanding. Does not exhibit appreciation of importance of children's devising strategies for themselves (beyond correcting wrong answers). **D.** Let children think on their own to motivate them or to develop their self-esteem. Does not exhibit appreciation of importance of children's devising strategies for themselves (beyond correcting wrong answers).
2	**A.** Let students think on their own. Exhibits appreciation of importance of children's devising strategies for themselves. This practice will be used sparingly; OR rationale is not well developed **B.** Let students think on their own. Students' approaches will be as legitimate as the teacher's. Unclear how much this practice will be used.
3	Let students think on their own. Exhibits appreciation of reasons children's devising strategies for themselves is important. This practice will be common in the classroom—used often.

Figure 3.2: Sample IMAP Scoring Sheet

The first rubric summary shown, (B5-S5), measures the evidence that students can solve problems in novel ways. The teacher's confidence that the student can solve a given problem is being measured. The second summary, (B7-S5), still deals with how children learn and do mathematics, but this summary is more concerned with what the respondent believes to be the role of the teacher. It is possible that a respondent will feel that a child can solve a problem (Belief 5) but that the child needs to be shown how to solve it (Belief 7). This example illustrates how the same item can yield two different scores.

After scoring the individual items, a rubric of rubrics was used to assign an overall score for each specific belief. The authors of the survey felt that simply totaling or averaging the scores was insufficient. These methods did not take into account the strengths of the beliefs; therefore, the rubric of rubrics was created (Ambrose, et al., 2003). Finally, the beliefs within the major categories (MCs) were averaged for each teacher. Since there is no way of knowing if one belief within a MC is more indicative of that category, the average provides a useful measure.

Before moving on, it is worth noting that I was an original coder on the IMAP project, and the IMAP project members trained me. Before coding my data for this study, I reviewed the training materials again to ensure the coding was done accurately. Therefore, no reliability test was done for this measure. The reliability of the survey in the original study was 84% (Ambrose, et al., 2003; Philipp, et al., 2003).

MATH STORY INTERVIEW

Each of the eight novice teachers was interviewed regarding their relationship with mathematics. The interviewer asked each respondent to recount various events in her experiences with mathematics. The events include a peak experience, a nadir experience, and a turning point. Challenges, along with positive and negative influences, are also included in the protocol. The final question allows the respondents to speculate as to their positive futures *and* negative futures with mathematics (Drake, in press; Drake, et al., 2001; McAdams, 1993). The interviews lasted anywhere from 30 minutes to one hour. Some of the interviews took place before the teacher took the IMAP survey and some took place after. All the interviews were completed within three weeks after the teacher took the IMAP survey. I conducted all the interviews; they were audio recorded and then transcribed. Table **3.1** provides a sample of the questions used in the interview. A complete version of the math story protocol can be found in Appendix A.

Event	Description
High Point	A high point would be a peak experience in your story about math in your life. It would be a moment or episode in the story in which you experienced extremely positive emotions like joy, excitement, great happiness, elation, or even deep inner peace after some math experience. Tell me exactly what happened, where it happened, who was involved, what you did, what you were thinking and feeling, what impact this experience may have had upon you, and what this experience says about who you were, or who you, are as a teacher.
Low Point	A low point is the opposite of a peak experience. Thinking back over your life, try to remember a specific experience in which you felt extremely negative emotions about math. What happened? When? Who was involved? What did you do? What were you thinking and feeling? What impact has the event had on you? What does the event say about who you are, or who you were, as a teacher?
Life Challenge	Looking back over your life and interactions with math, please describe the single greatest challenge that you have faced. How have you faced, handled, or dealt with this challenge? Have other people assisted you in dealing with this challenge? How has this challenge had an impact on your experiences with math?
Positive Future	Describe a positive future, that is, what you would like to happen in the future with regards to your interactions with math, including what goals and dreams you might accomplish or realize in the future.

Table 3.1: Sample Math Story Interview Protocol

Coding the Math Stories

Coding of the math stories involved using the coding protocol developed by Drake (in press) and later modified (Sherin, et al., under review). To aid in the coding, each event (e.g., peak, nadir, turning point, etc.) for the teachers was entered into a database. Three events—peak, nadir, and turning point—were coded for tone, timing, and specificity (Drake, 2006; Drake, et al., 2001). Tone was coded as positive, negative, or neutral. Statements containing key words for positive tone (e.g., love, like, enjoy) or negative tone (e.g., hate, detest, boring) were counted. If an event had an equal number of statements containing these key words, then it was coded as neutral. Timing was defined as "early" if the event happened before entrance into college or "recent" if the event happened while in college or after. As they were novice teachers, I felt this distinction provided enough of a time spread for each category. If they were more experienced, I might have defined "recent" to include their teaching career only, but that did not seem necessary for teachers so new to the profession. Specificity was coded using a four-point scale for each of three dimensions: mathematics, timing, and setting. See Table 3.2 for more detail.

	Mathematics: Extent of focus on mathematical content	**Timing:** When the event happened	**Setting:** • Who was involved • What happened • Where • What respondent was thinking and feeling
Non-Specific	No mention of mathematical content	Mentions very general stage of life (e.g., high school)	Describes 1–2 of the Setting criteria
Moderately Specific	Mentions course title (e.g., algebra, geometry)	Mentions the year (e.g., third grade)	Describes 2–3 of the Setting criteria

Fairly Specific	Mentions topic within the course (e.g., equations in algebra)	Mentions the season or week (e.g., end of third grade)	Describes 3–4 of the Setting criteria
Specific	Mentions specific details related to topic (e.g., isolating variables on one side of an equation)	Mentions specific day or class period	Describes 4–5 of the Setting criteria in detail, providing a strong image of the event

Table 3.2: Four-Point Scale for Coding Specificity in the Math Story (Sherin et al., under review)

After each of the dimensions was given a code (1–4), they were averaged to obtain an overall score for specificity. Each story was then assigned one of nine categories based on the individual teacher's descriptions of her early experiences (positive, negative, or neutral) and her current perceptions about mathematics and pedagogy. (See Table 3.3.)

	Current Perceptions: Learning about teaching mathematics and learning about mathematics	**Current Perceptions:** Learning about teaching mathematics only	**Current Perceptions:** Negative
Early Experiences: Predominantly negative	Turning Point	Foreclosed	Frustration
Early Experiences: Mixed positive and Negative	Roller Coaster	Satisfied	Resignation
Early Experiences: Predominantly positive		Self-confident	

Table 3.3: Nine Categories for Experiences and Perceptions about Math and Pedagogy (Drake, 2006; Sherin, et al., under review)

This table is a combination of Drake's initial table and Sherin et al.'s modifications. Sherin et al. added the row for predominantly positive early experiences.

The boxes that have no label mean that in neither study there was not a teacher who fit the specific criteria.

After the initial round of coding, the stories were analyzed again, this time to identify a theme, or a common thread that runs through each of the stories. McAdams (1993) uses the term *myth* when describing a theme. He says that from birth, humans have experiences that will have an effect on them in later years. Most likely, they will not be aware that they are gathering experiences or that particular experiences will turn out to be especially significant. Not until the mid-teen years do individuals become aware of the context of their myths and how their experiences play a role in the creation of these myths. Bruner (1994) discusses something similar when talking about "reconstructing self"; he describes how individuals or writers are not just concerned with getting their stories right, but also with providing continuity to them. To find a theme, I looked at *all* the events in each math story (as opposed to the high point, low point, and turning point, as described earlier) and identified the main issue or issues (Sherin, et al., under review). Using a database aided with this task because it allowed me to view one event at a time so as not to be influenced by another event.

I recorded the prominent issues for each event. "Need for structure" or "Do not want students to feel like I did" were common issues. I looked for patterns within each teacher's issues and assigned a theme. I found themes for seven teachers, and I then applied the theme coding criteria developed by (Sherin, et al., under review). For one of the teachers, I could not identify one distinctive pattern among her issues. Not coincidentally, her interview also took the least time to complete, so her story was the shortest. I assigned each of the teachers a broader theme type utilizing Sherin et al.'s types: teaching for understanding, external factors affecting learning, and holding onto the past. I did create a fourth theme type, learning from the past, because one of the teachers, Carrie, had this theme running throughout her story. As she reflected on her story during the interview, she began to realize that, while she did well in the mathematics classes before calculus, she did not truly understand the mathematics because she had just memorized procedures.

Coding Math Stories for Beliefs

Coding for story types and themes already had an established procedure in existing literature. Coding the math stories for specific beliefs did not have an established procedure. I initially started to read through the stories, trying to discern any beliefs related to the teaching of mathematics to children. This was a very difficult task because there are too many possible beliefs, and, since my goal in the study was to compare the measures, it made sense to use the same beliefs in both measures. For that reason, I decided to use the seven research-based beliefs that were used in the IMAP survey.

I applied the rubrics used to code the IMAP survey not only to give me an idea of what constituted strong evidence of a belief but also to determine what would indicate an absence of strong evidence. Using the rubrics, I wrote the opposite of each of the seven beliefs. They were not the exact logical opposites, but they were descriptive enough that I could identify evidence or the lack thereof in the teachers' stories. This provided a way to establish a level of conviction for the belief.

The IMAP survey and its rubrics were already constructed to identify this evidence of belief. The math story interviews were not. I needed to make sure I could identify when there was little or no evidence of a belief in the stories. To do that I needed to know what *not* having the beliefs looked like. This allowed me and other coders to assess the evidence on a continuum. Table 3.4 shows the seven IMAP survey beliefs and what the absence of having the belief would look like.

IMAP Beliefs	***Absence of belief***
Mathematics, including school mathematics, is a web of interrelated concepts and procedures.	Mathematics, including school mathematics, is just a set/list of procedures to be memorized with little connection to one another or to the concepts.
One can perform standard algorithms without understanding the underlying concepts.	Students understand concepts if they can perform the standard algorithm (understanding = proficiency with algorithms).
Understanding mathematical concepts is more powerful and more generative than remembering mathematical procedures.	Remembering procedures is more generative than (or even as generative as) understanding concepts.
If students learn mathematical concepts before they learn standard algorithms, they are more likely to understand the algorithms when they learn them. If they learn procedures first, they are less likely to learn the concepts.	Learning the concepts first will not help a student learn the algorithms.
Children can solve problems in novel ways before being taught how to solve such problems. Children in primary grades generally understand more mathematics and have more flexible solution strategies than their teachers, or even their parents, expect.	Children have to be taught the skills and procedures before being asked to solve problems.
The ways children think about mathematics are generally different from the ways most adults would expect them to think about mathematics. For example, real-world contexts, manipulatives, and drawings support children's initial thinking whereas symbols often do not.	The way I learned mathematics will work for my students. Children can learn mathematics symbolically without first using manipulatives, drawings, or real-world contexts.
During interactions related to the learning of mathematics, the teacher should allow the children to do as much of the thinking as possible.	The teacher should show or tell the student step-by-step how to solve a problem.

Table 3.4: IMAP Survey Beliefs and the Absence of the Beliefs

With these parameters identified, I was able to comb through the events in the teachers' lives and assign a belief as well as a level of evidence for that belief.

To code levels of evidence, I decided to use a scoring system from 0, indicating no evidence of the belief, to 3, indicating strong evidence of the belief. To be clear, I was looking for indications of the seven IMAP beliefs. The opposite beliefs I wrote were just a guide. Using the letters A through G for the beliefs and the numbers 0 through 3 for the level of evidence for the beliefs, the codes comprised a letter representing the belief and a number representing the strength of evidence. For example, "A2" meant the first belief is evident and the evidence is strong that the teacher holds the belief. "C1" meant Belief C is evident, although the evidence is closer to the opposite belief than the original.

The streamlined codes made coding easier, but it was still an onerous task because it was possible for a given event (e.g., peak, nadir, challenge, etc.) to reflect more than one belief. So, for each event in the teachers' stories, the coder was looking for evidence of any of the seven beliefs at any of the four evidence levels.

Another aspect that made coding difficult was the fact that these stories were not intended to be belief surveys. Beliefs were not specifically asked about, as this was not the purpose of the math story. As stated in chapter 2, there is merit in looking for beliefs in teachers' stories because the case can be made that these beliefs come up naturally in the narrative (Drake, et al., 2001; McAdams, 1993; Spillane, 2000) and can be viewed differently than those gathered through IMAP survey.

After the stories were coded for beliefs, they were sent out for reliability checks. I used four coders who were familiar with mathematics reform so that there would be no need to provide lengthy explanations regarding what the beliefs meant. I gave the coders only those segments (i.e., parts of an event) where a belief or beliefs were found. The goal of the reliability check was to see if the other coders saw the same beliefs in the segments that I had seen. It was not to see if they would find the same segments that I had found. Thus, the coders understood that, in all the segments they received, I had assigned at least one code. I divided up the eight teachers into groups of four and sent each coder four teachers. Each pair of coders received the same four teachers, thus assuring that each teacher was coded by three different coders (myself and two others). The coders used the same letter-number coding system I used. I sent the coders the seven beliefs as well as the opposite beliefs. I also sent them a short description of what I was looking for when I coded the beliefs. Because of variations in stories, some teachers only had six coded segments while others had around fifteen. So I also made sure all four of my coders had roughly the same number of segments. The coders sent back their responses. The data were then entered into a database to aid in the analysis.

Once all the results of the coding were collected, I compared the agreement among the MCs of beliefs:

1. Beliefs regarding the nature of mathematics (Belief A)
2. Beliefs about the knowing and learning of mathematics or both (Beliefs B–D)
3. Beliefs about children (students) doing and learning mathematics (Beliefs E–G)

Initially, I started comparing the individual beliefs, but certain problematic situations caused me to change to comparing agreement among the MCs. The following excerpt is a segment from one of the teacher's math story along with the subsequent codes from all three coders.

> They get that, because they can see it. They get it when they have cubes in front of them. Most of them do. All of that, if I hadn't learned that in college from people like xxxxx* and people like xxxxx, if I hadn't learned that, I wouldn't teach that way, because I was never taught that way. But I really learned that that's how kids learn. They have to see it. They have to manipulate it. They have to understand it. (Carrie MS, lines 329–334) (*names deleted to protect anonymity of respondent)

My Code	Coder 1	Coder 2
F3	E2, F3	F3

All three coders agreed that Belief F was present, but Coder 1 also found evidence of Belief E. Beliefs E and F are both in the same MC. I was not sure if this counted as agreement or not. I encountered many other incidents such as this one. The obvious solution was to just look for agreement among the MCs and see what data it provided. I knew I could go back and code for agreement among specific beliefs later.

After this process was established, I ran into another problem with determining agreement. The following segment shows actual data from Elaine's math story that illustrates the issue.

> I just remember having projects like this. I don't remember what other kinds. We did some area projects. We had a Math Day at our school that she helped organize, where we brought in the toilet paper rolls, toothpaste, any kind of cardboard box, that kind of thing, and we built buildings and whatever kinds of things. They gave First Prize to the most creative and that kind of thing. She just made it more real-world. It wasn't just so monotonous. Like, "Okay. Here's your worksheet of things." Like, we had little goals to achieve. (Elaine's MS, segment 8, lines 443–449)

The original codes for this segment appear in the following table.

My Code	Coder 1	Coder 2
A3	A3	A3, F2

My concern was not in assigning a final code for this segment but in ensuring accurate representation of the agreement among the coders. Therefore, I decided to take segments that had codes from different MCs and compare the codes individually. The following chart shows how this was done.

Segment	My Code	Coder 1	Coder 2	Agreement
8	A3	A3	A3	Agreement
8.1	A3	A3	F2	No agreement

Again, the purpose was to present evidence of agreement. Of the 139 comparisons, the coders had only disagreed in 11 (~8%) on the MC. At least two coders agreed in 92% of the comparisons, and 77% of the comparisons showed agreement between at least one of the other coders and me. These numbers were very encouraging for a new process. The last step was to assign a final MC code (1, 2, or 3). I looked for agreement between at least two of the coders, and I assigned the segment the agreed-upon code. After the MC codes for a given section were assigned, I focused on determining the level of evidence, rated 0 through 3, of the MC in each segment.

Level of Intensity

The process for determining level of intensity was not as involved as the previous one; however, I needed to make some decisions. For level of intensity, I used all the belief codes for a given MC to ensure that the appropriate level of evidence was attributed to the assigned MC. To aid in the coding, I created a spreadsheet. Table 3.5 illustrates the organization of the spreadsheet.

tchr	segment	mycode	coder1	coder2	combined codes	MC1 level	MC2 level	MC3 level		MC1 level	MC2 level	MC3 level
4	1	A2	A1	A3	A2;A1;A3	2				2		
4	2	A0;B0	B1	NC	A0;B0;B1	0	0.5			0	0	
4	3	C1	A2;B2	A2	C1;A2;B2;A2	2	1.5			2	1	
4	4	E1;G1	B1	E0;G0	E1;G1;B1;E0;G0		1	0.5			1	0
4	5	A3			A3	3				3		
4	6	C2	C2	C2	C2;C2;C2		2				2	
4	7	G2	F1	F3	G2;F1;F3			2				2
4	8	G0	E1	C1;G1	G0;E1;C1;G1		1	0.67			1	1
4	9	G0	C2	C2; G1	G0;C2;C2;G1		2	0.5			2	0
4	10	C2;G1	C1	G1	C2;G1;C1;G1		0.5	1			1	1
4	11	A2	D3	C3	A2;D3;C3	2	3			2	3	
						1.80	**1.44**	**0.93**		**1.80**	**1.38**	**0.80**

Table 3.5: Sample from Level of Intensity Spreadsheet

The shaded columns on the left shows all the levels for each MC averaged together. No numbers were excluded, even if there were multiple beliefs from the same MC. The shaded columns on the right are another way I analyzed the data; the level was decided by taking the mode of the levels within each MC. If there was more than one mode, I took the lower of the two. I decided to err on the low side so as not to overestimate the level of evidence. For example, in event 4, four of the six codes are in MC3: E1, G1, E0, G0. Since the modes are 1 and 0, I assigned a level of 0. After I assigned levels to each MC for each teacher, I averaged the levels. These averages are shown in the bottom row of the table. The averages for this teacher, including the section in which I averaged the levels (left) and in which I used the mode (right), are very close. This was true for all the teachers. Since the averages were so close, it solidified my decision to use the averages. I wanted to use a simple, yet consistent, process to determine the level of intensity. The experiment with the mode was intended to determine what information it would yield.

Since the information was so similar to the average, I decided to use the average. These averages and the IMAP survey averages comprise the statistical data for this study.

ANALYZING THE DATA

Below I describe my analysis that led me to my findings. I include my first pass through the data looking at quantitative data even though it did not lead to any significant conclusions on my part. I felt it was an important piece of the story because someone else who reads this story has the opportunity to modify and take further what was started in this study. Stories are meant to transfer information from generation to generation (McAdams, 1993) so I want to make sure I hold up my end of the bargain.

Quantitative Analysis

The analysis went in different directions the first few passes through. Initially, I averaged the levels of intensity for each of the three major categories (Table 3.6). This was not standard protocol for the IMAP survey. I decided to find the averages because it became apparent to me that the major categories provided enough detail from which to examine the relationship between the instruments, especially since the coding for the math stories was a new venture, I felt that trying to compare the seven specific beliefs should be left to the "after the dissertation" phase of my life.

Teacher name	IMAP MC 1 Score	MS MC 1 Avg	MS MC1 count	**IMAP MC2 avg**	**MS MC 2 Avg**	**MS MC 2 count**	*IMAP MC 3 avg*	*MS MC 3 Avg*	*MS MC 3 count*	Total occurrences of all MC in math stories
Elaine	3	2.35	4	**3**	**2.2**	**6**	*1.67*	*1.83*	*6*	16
Carla	2	1.8	4	**1**	**1.44**	**8**	*0*	*0.93*	*5*	17
Kim	3	2.15	2	**3.33**	**2.1**	**3**	*3*	*1.53*	*3*	8
Dottie	0	1.99	2	**0.67**	**1.42**	**16**	*0*	*0.17*	*15*	33
Lana	1	1.89	3	**0**	**2**	**1**	*0.33*	*1.73*	*4*	8
Patty	1	2.56	4	**2**	**n/a**	**0**	*2.33*	*2.55*	*10*	14
Sasha	3	1.86	3	**1.33**	**1.38**	**6**	*1*	*0.87*	*6*	15
Carrie	2	1.14	5	**2.67**	**2.15**	**11**	*1*	*2.57*	*6*	22
		Total	27		**Total**	**51**		*Total*	*55*	113

Table 3.6 Comparison of IMAP and Math Story Levels of Intensity

As this was not the ultimate direction I ventured, I will not go into further details. While, in theory, this type of analysis could prove useful, the math story coding is not sophisticated enough to produce statistically significant results. This is not to say that the information gained from the coding of the math stories did not aid in the analysis. It just pushed me to take a more qualitative approach to examining the data.

Analyzing the data qualitatively

The next phase of analysis led me to just look at the statements where beliefs were found in the math stories and try to observe a pattern among these statements. It was this type of analysis that would eventually lead to the findings in Chapter 4. Reflecting back on this process, I realize that because I believed the IMAP survey to be a valid source of beliefs, their results acted as the filter through which I was viewing the teacher stories. What I mean is for each of the teachers, I was looking for evidence in the math stories to aid in explaining the results from the IMAP survey. This narrowed the focus of my analysis of the math story belief segments and allowed me to find, what I consider interesting, information about the teachers.

CONCLUSION

It is difficult to clearly explain the process I used to analyze the data because the initial goal of the study was simply to explore the relationship between these two sources of data. This left quite a bit of room with which to work and while I like the freedom associated with this type of analysis, for research it proved more difficult to report findings befitting a dissertation. What I present in the next chapter are stories of three teachers. These stories illustrate information that can be discerned when utilizing the open analysis discussed above. The findings do not claim to be the *only* kind of information that can be reported. As stated several times in this document, a people's beliefs and experiences influence the decisions they make. My experiences as a elementary mathematics methods instructor and beliefs about what is important to know about my students influenced the decisions I made regarding what constituted a finding.

Chapter 4: Findings

This chapter provides answers to the three research questions stated at the end of chapter one. The structure of this chapter is simple; I will answer each of my three research questions separately. One major finding is that the math story can be coded for specific beliefs and that these beliefs do not necessarily correlate with the results from the IMAP survey. This is not meant to say that the IMAP survey is incorrect, but just that the math stories provide more in-depth understandings of the teachers' beliefs because the stories explore teachers' experiences as both students and teachers of mathematics. This is a positive result as it furthers the claim that these two tools used in conjunction can provide more information than using just one. Furthermore, math stories can provide insight into the trajectory of teachers' beliefs and the power of emotions on the beliefs reported in the IMAP survey.

QUESTION 1: WHAT KINDS OF SPECIFIC BELIEFS CAN BE IDENTIFIED IN ONE'S MATH STORY

The answer to this question is straightforward. I found beliefs in the teachers' math stories that corresponded to each of the three major categories of beliefs in the IMAP survey:

1. Beliefs about the nature of mathematics
2. Beliefs about teaching and learning mathematics
3. Beliefs about how children think about and do mathematics

Table 3.7 illustrates the number of segments within each teacher's story that contained evidence of beliefs from each of the three main categories. Patty is the only teacher for whom beliefs were not found for all three major categories. For MC 2, beliefs about teaching and learning mathematics, she had zero instances that indicated evidence of beliefs. Given the fact that evidence of beliefs from all three major categories were found for all the other teachers in the study, this could be an interesting situation to follow up for further study either with specifically Patty or in general to explore what it means (if anything) if a teacher's math story lacks evidence of a particular belief or set of beliefs, especially since the vast majority of her belief segments were in MC 3, beliefs about how children think about and do mathematics.

Teacher's Name	No. of MS Belief segments major category 1	No. of MS Belief segments for major category 2	No. of MS belief segments for major category 3
Elaine	4	6	6
Carla	4	8	5
Kim	2	3	3
Dottie	2	16	15
Lana	3	1	4
Patty	4	0	10
Sasha	3	6	6
Carrie	5	11	6
Totals	27	51	55

Table 3.7 Number of Segments in Math Stories to Contain Beliefs, Disaggregated by Major Category

QUESTION 2: WHAT IS THE RELATIONSHIP BETWEEN BELIEFS FOUND IN TEACHERS' MATH STORIES AND THOSE FOUND USING THE IMAP SURVEY?

Teacher name	IMAP MC 1 Score	MS MC 1 Avg	**IMAP MC2 avg**	**MS MC 2 Avg**	*IMAP MC 3 avg*	*MS MC 3 Avg*
Elaine	3	2.35	**3**	**2.2**	*1.67*	*1.83*
Carla	2	1.8	**1**	**1.44**	*0*	*0.93*
Kim	3	2.15	**3.33**	**2.1**	*3*	*1.53*
Dottie	0	1.99	**0.67**	**1.42**	*0*	*0.17*
Lana	1	1.89	**0**	**2**	*0.33*	*1.73*
Patty	1	2.56	**2**	**n/a**	*2.33*	*2.55*
Sasha	3	1.86	**1.33**	**1.38**	*1*	*0.87*
Carrie	2	1.14	**2.67**	**2.15**	*1*	*2.57*

Table 3.8 Comparison of Average IMAP and Math Story Scores Within Each Major Category

Table 3.8 indicates that strength of evidence of beliefs found using the IMAP survey does not necessarily match the strength of evidence of beliefs found in the teachers' math stories. There are instances when the IMAP average and math story averages are similar (e.g. Carla, MC 1 and 2) and others where difference between the averages is wide (e.g. Lana, MC 3; Sasha, MC 1). These results would be discouraging if the purpose of this study was to show a direct correlation between the two measures. Luckily for me, that was not the purpose of the study. These results are encouraging because they provide further evidence for my argument that using both instruments to view beliefs will provide more information about teachers' beliefs than only using one, which leads to question number 3.

QUESTION 3: WHAT DOES LOOKING AT BOTH SOURCES TELL US ABOUT A TEACHER'S BELIEFS THAT EXAMINING JUST ONE SOURCE WOULD NOT?

To answer this question I will show that math stories aid to "unpack" the results from the IMAP survey. The data from the IMAP survey shows that some teachers have similar beliefs within the major categories. Math stories can aid in examining those teachers and show that the beliefs are not necessarily the same or even come from the same experiences. That is, the same beliefs can have a different history and a different emotional intensity. Evidence for this claim comes from the stories of Lana and Carla. Their IMAP scores were very similar, especially major category 3. Their math stories show that the path these teachers took in developing these beliefs were dissimilar. Also evident from using the math stories along with the IMAP survey, is the powerful role of emotion in the development of beliefs and how even one event can change the way a person views mathematics, even if that view had lasted for several years. This finding will be exemplified by Carrie's story. Her IMAP scores are very high, which may indicate a very positive relationship with mathematics, but her story tells a different tale.

Providing A Sense of Trajectory

This section will illustrate how the math story helps distinguish between two teachers who have similar IMAP survey scores. The survey indicates that Lana and Carla have similar beliefs regarding how children think about and do mathematics. Carla's score about the nature of mathematics is higher, but at a quick glance one could logically assume they possess similar kinds of beliefs. What the IMAP survey does not portray is the path these two teachers took leading up to becoming educators and how these beliefs may have been formed. Their stories have a similar theme, that of structure, yet their experiences as students are quite different. Understanding these teachers' different experiences provides an opportunity to better inform their beliefs about mathematics, in particular those regarding how children think about and do mathematics. One way to inform these beliefs might be through teacher professional development. The structure of this section will be discussions of similar events within Lana and Carla's stories. First is their stories as students, where the need for structure began followed by their stories as teachers and how this need manifests itself within their views of teaching.

Need for Structure/Clear Expectations – Lana's Learning Experiences

Structure is the prominent theme of Lana's math story. The structure she craves comes from a need to know exactly what is expected of her. Once she understands the expectations, she can proceed to meet them. Her experience in seventh grade appears to mark the beginning of this need for structure. This notion of structure is reflected in the following quotes, which illustrate the turning point in her relationship with mathematics.

The first quote discusses her frustration with the teacher's unwillingness to allow Lana to solve problems in a way she understands.

> But one thing about her (this leads into when I had her though) she had her way of doing things. If you could take a test, solve the problems, and get the right answers, but you didn't do them her way, the way she taught you, then you were penalized for that. That's a huge thing that I remember, [is] not being able to understand. If I can do it, what does it matter how I do it, as long as I can do it and explain myself? (Lana MS lines 98-103)

The next quote from Lana's math story exemplifies the turning point:

> With the same class, I can't say it was a specific day that something happened, but I just remember loving math after that. I think it was because the same teacher expected so much and I knew that to do a good job in her class, I had responsibilities. I think maybe the pressure or the expectations were there, and that's why for some reason I just loved math after that. I took every math class with her after that. I don't know. It was very strange, because I cannot say there was one specific moment. (Lana MS, lines 118-120)

Once Lana understood what was expected of her, she had two choices: meet them or fail. She chose to meet them. From this point on, she needed structure to succeed. To Lana, structure meant that clear expectations were set. When she was with a teacher who did not set clear expectations, she floundered. An example from her math story is when she discusses taking college algebra as a freshman. In this reflection, Lana clearly blames her teacher for the C she received because the teacher did not have clear-cut expectations of her students.

> I can see her in my head. She was very easily swayed. She changed her mind a lot. There were no expectations set. There were no . . . I don't know. It was just different from any other teacher I had had, because they said, "*This is what I expect you to do. It's going to be done on this date. That's it. That's the grade you're going to get.*" She wasn't like that. It was kind of like, "*Well, let's do this. If we can't do that, then we'll do this.*" I

> needed structure, and I don't think it was very structured." (Lana math story interview, Lines 123-127)

Need for Control: Carla as a Student

Like Lana, a theme of structure and expectations runs through Carla's story. Carla's recollections from her time in school talk about her success with teachers who set high expectations and her dislike of teachers who did not. Where Carla's story diverges from Lana's is that Carla's need for structure tends to be for disciplinary control, whereas Lana's need for structure regards expectations. The excerpts from Carla's story show that she needed to have strong discipline in the classes she took as a student. She also finds a great deal of satisfaction in meeting high expectations. These experiences carry over to her classroom.

She talks about a geometry class she took in high school. During the first semester she had a teacher whom she had the year before in algebra. That experience did not go well—not because of the mathematics but because of the teacher's lack of control.

> I don't remember her teaching. Every so often she would get up there, but she had no control over the class, so it was just more spent yelling at people for talking. (lines 118-120)

Carla was frustrated because she felt she was not getting the foundation she needed for algebra II. Luckily, this event didn't have a negative impact on her because when she went to Algebra II, she had a good teacher who was able to maintain control.

Carla's positive experience started halfway through the geometry class mentioned above, then she was moved into the honors geometry, where she found success.

> The second semester of high school, I got moved to the Honors Geometry class, which I was someone who could do it, but was going to have to work harder, and the teacher was much better in there. So it was a really hard class for me and I really, really had to

> work for it. As a lot of things in life, when you really have to work for it and you get it, it means a lot more. So she was just a really good teacher and I really enjoyed having her. But it's probably the same just because I felt like a sense of accomplishment. Like yeah, I had to work really hard, but when I got it, it meant a lot more to me than something that just came easy. (lines 41-49)

This excerpt shows that Carla's positive feelings came from a sense of accomplishment because she had to earn her grade. The teacher was strict and had high expectations for the students, and Carla strived to meet them. This enthusiasm continued on into Algebra II. She said math was fun again.

Comparison of Lana and Carla's Experiences as Students

From the excerpts of their stories presented above, Lana's need for structure appeared to result from her frustration with her teacher's reluctance to accept Lana's alternate solutions. Lana felt that if she could explain her solution clearly and it was correct, then it should be accepted. However, she clearly decided to conform to her teacher's methods when she says that the class became easier when she understood what was expected of her and began solving problems the way the teacher dictated. Carla, on the other hand, always appeared to have this requirement of her teachers to have control of the classroom and set clear expectations that she could meet. Throughout her story the need for the teacher to maintain control was consistent. There was not an event where she had an "Aha!" moment as Lana did regarding what she needed to succeed. It was always there. Their experiences as students foreshadow how they see their roles as teachers of mathematics.

Lana's Need for Structures: Connections to Her Teaching

When Lana discusses her teaching she expresses strong emotions from seventh grade when she was not allowed to use her own thinking; even though she eventually grew to like that teacher, she does not want to be so strict with her students.

> I try not to be like that with my kids. But like I said before, I find myself sometimes frustrated that they can't finish their work. But I'm a lot more lenient in the fact that as long as they know how to do it and they can explain it to me, they can have their own methods and strategies. I'm not so, "I taught you how to do it this way, and this is the way you're going to do it." (Lana MS, lines 87-89)

The next quote also mentions another frustration she feels when planning her lessons:

> The one that is freshest on my mind is coming to this school not having an education background and learning to do Math Investigations with my kids. Because it's so different than the way that I learned how to do math. It was just very challenging for me. I would have to sit at home and read the lesson over and over and over again and even asked my husband to help me. "How do I explain this to fourth graders? How do I present it?" I knew what to do. But it's just presenting it to nine- and ten-year-olds that's kind of difficult. (Lana MS, lines 70-73).

These excerpts illustrate the conflict that Lana faces as a teacher, which can be directly linked to her time as a student. She wants to allow her students freedom to solve problems using their own strategies, yet she agonizes over how to present the information to her students in a manner different from when she was taught. Carla does not appear to have these conflicts. She transfers her expectations when she as a student to her role as a teacher. The excerpts below illustrate this point.

Carla's Views as a Teacher

As a teacher, she talks about setting high standards for her students and expecting them to be met.

> I've told my students what I just said. My job is to teach you. It's not to be your friend. If we get along, that's bonus. But as long as you learn from me, then I consider that I've fulfilled my obligation to you. Know that I do care about you, but we're here to work. (lines 182-185)

While this view may sound harsh, Carla sees it as her way to show she cares about her students. She feels her job is to push them to achieve their potential, just as her teachers pushed her to work and think. Those were the teachers she respects that most.

Furthermore, Carla does enjoy teaching and thinks it is fun. When asked about her philosophy, she responds that does not want her students to spend much time listening to her. She will teach her lesson, then let the students work on problems while she circulates. Part of her philosophy comes from the district-mandated curriculum, but another part comes from her dislike of just sitting around.

> [J]ust for my own sanity. If I just sit there and expect them to be quiet and do it, it's not happening. I'm going to fight the discipline issues. It's not necessary for them just to sit there, but to let them talk and get up and move. I can't stand to be still that long, so I know they can't. Part of it is just personality. Part of it is just our curriculum and the district dictates it. (lines 334-342)

Conclusion

These two teachers have similar levels of beliefs based on the IMAP survey. Their math stories show similar themes, but have different effects on them as teachers. Carla's beliefs about the role of the teacher appear to be more entrenched as indicated by a fairly strong correlation between the beliefs found via the IMAP survey and beliefs evident in the math story. The relationship between Lana's results is not quite as linear. The IMAP indicates that she adheres to a very teacher-centered approach to teaching. Her math story however indicates a willingness to allow students some autonomy. It is this "thread" that could be pulled for the purposes of professional development, by helping her realize that she can provide her students clear expectations while allowing them to solve problems using their own strategies. Carla's beliefs seem a bit more entrenched and could be more difficult to adapt.

The Power of Emotions

Previous chapters discussed the role of emotion in the development of beliefs. The emotional response to an event or events in a teacher's life can color the lens that teachers use when making pedagogical decisions. Emotion becomes part of their belief structure, and if the emotion is strong enough, it can create a person who is very resistant to change. In Carrie's case, the emotions she felt as a high school student had a profound effect on her as a teacher—an effect of which she may not yet be aware. The use of the IMAP and math story help shed light on the effect and the seeming roller coaster she has taken concerning her beliefs.

Carrie: Emotions in the Math Story

Carrie says she liked mathematics up until senior year of high school. Before that time, she was very successful in classes such as Algebra II and pre-calculus because they involved memorizing formulas and plugging in numbers.

> I've always considered myself to be a really good student. I think the reason I was so successful at math at that stage with the pre-calculus and then Algebra II was it was all the formulas. It was memorizing formulas and being able to plug them in to appropriate situations. I was really good at memorizing and remembering things like that and being able to apply and analyze situations for fitting in formulas. (Carrie MS, lines 20-22)

When asked to be on the mathematics team in high school, she felt honored. Even though she did not do very well, she still considered it a compliment to being asked. These positive emotions towards mathematics ended when she had to change to a school in which she enrolled in AP calculus BC. This is where her dislike began and her frustration started to grow.

Because of her long history of success in mathematics, when Carrie switched schools for her senior year of high school, she signed up for the highest level of mathematics because that is where she felt she belonged. She quickly realized she was not in the right place.

> It just totally kicked my butt. I had no idea what to do, because I didn't understand what I was doing. I didn't understand math. I understood formulas. I understood how to memorize things. But I didn't understand the way things worked. All of the spatial things, being able to rotate a shape 180 degrees, I could not visualize that for the life of me. (Carrie math story, lines 56-60)

Here, Carrie acknowledges that she did not really *understand* mathematics. She realized that memorizing formulas and knowing when to use them was not enough. She also indicates that her difficulty occurred because she had trouble visualizing a solid rotating around an axis. Finding the volume of this solid is a common application of integration. From personal experiences as a student and a teacher of calculus, I know that this is a very difficult concept if the student cannot *see* the solid being formed by rotating a curve around an axis. Carrie says that the only way she was able to receive a B for the course was to have her boyfriend help her with extra credit. For someone who had received As all her life in mathematics, receiving a B in mathematics was a major blow for her. At this time, she truly started to hate mathematics.

> I just started to hate math. I really started to hate math. And I realized I didn't understand what I was doing. I hadn't understood that before. It frustrated me to not be able to figure something out, to not be able to problem solve something. (Carrie math story, lines 65-70)

Frustration and *hate* are strong words denoting negative emotions. She uses these words at different times in her math story and in her responses to the IMAP survey. The emotions Carrie expresses are not surprising. She had always been successful, and when she was not, she did what many students do: she blamed her calculus teacher for not giving her the tools to be successful. Even though she admitted in an earlier quote that she was not ready, she does not place any blame on her previous teachers. She recounted how she was successful in Algebra II because the teacher was creative in telling the class a story to help them learn about *i* and because the teacher taught them a song to help them remember the quadratic. She credits her success in pre-calculus to her success in Algebra II, even though her pre-calculus teacher taught the same way as her calculus teacher, straight from the book.

Carrie: Emotions in the IMAP

Carrie's strong emotions regarding mathematics are evident in the IMAP survey. Segment 5 of the IMAP survey asked the respondents how they felt when asked to solve a problem in mathematics, which they had not been previously shown how to solve. The frustration in Carrie's response is very evident:

> Frustration, anger at the teacher, feeling stupid. If the teacher did not provide the proper tools for solving a problem, I thought it was something I was supposed to already know and felt stupid and defeated for not being able to solve the problem. (IMAP survey, segment 5.0)

When she could not solve a problem, she felt "stupid" and "defeated" because she felt she should know how to solve it already. She blames the teacher for not preparing her adequately. Carrie felt that if a teacher presented a child with a problem to solve, then the child should know exactly how to solve it. Knowing how to solve it came from the teacher. This is evident in her response to the next segment of the survey that asked if she would ever ask her students to solve problems without first showing them how to solve it.

> I would only do this if the problem were similar to ones we'd done before. And then, I would give the students a challenge to use what they know to try to solve the problem. After a short time, I would discuss the problem with them and, together, we would find a good way to solve the problem. I would not let my students flounder or begin to feel frustrated and defeated. (IMAP survey, segment 5.1)

Even though Carrie replies "yes" to the question, she qualifies her response by saying "only if it was similar to ones we'd done before." The fact that she uses words identical to how she felt as a student—"frustrated" and "defeated"—punctuates how her emotions colored this response and possibly her beliefs regarding the ability of students to solve problems using their own knowledge and understanding.

Carrie's response to segment 5 indicates that she doesn't want her students to struggle like she did and, thus, will not have them solve problems without showing them how to at least solve similar problems. Nothing in Carrie's math story contradicts this assumption. The math story conveys a possible source of her frustration and an evolution of this feeling when she realized that she did not understand as much mathematics as she thought. This occurred in her math story when she was describing a turning point in life, Carrie predictably identified her BC calculus class. Her frustration throughout that year grew to the point where she didn't even finish the free response questions on her advanced placement exam (she wound up taking the AB test instead of BC). She says it was the first thing she remembers ever giving up on academically. When Carrie was asked what impact she felt this experience had on her, she stated her burgeoning understanding of her mathematical preparation.

> It was funny, because I almost bragged about it, because I'd never done anything like that. It was like I was being rebellious. To be honest with you, I think it was good for me to just say . . . not just say, "Oh, I'll never do calculus again," but to just realize that I wasn't prepared. I didn't have the tools for it. And to look back and say, "Okay. How could I have been more prepared? How could I have gotten the tools for it?" I don't want to blame it all on the teacher. I think it goes back further than that, because a lot of people who had the same teacher got it. I mean, she was teaching to those kids who got it. (Carrie, MS lines 100-107)

The key phrase, "I think it goes back further than that" shows that she is open to the notion that success in her mathematics classes before calculus did not mean she truly *understood* the mathematics. So, the frustration she mentions in her IMAP survey may partly stem from her lack of success in calculus, but it may also result from the shattering of her belief that she was adept at mathematics.

This quote from her math story is critical not only because it sheds light on her continued feelings of frustration when recalling her time in BC calculus, but also is another "thread" to pull on. She acknowledges that it was not all her calculus teacher's fault and begins to place some of the blame on the teachers she had before. These were teachers she praised in her story, yet she is introspective enough to realize that not telling students how to use the algorithms and formulas may benefit them in the future. The next step would be to help her see how to accomplish this, by building on this segment of her story. It will not be easy because her emotions about her time in twelfth grade as still strong, but she has laid the groundwork for her to move past it and provide her students with effective learning experiences.

CONCLUSION

This chapter illustrates the use of math stories and the IMAP survey in conjunction. The IMAP survey provides numerical data to represent teachers' beliefs, however the numbers do not tell the whole story. The math stories are a way of examining the path teachers take with regards to mathematics and allows whomever is using the tools to find small "threads" to pull and help the teachers move towards having the beliefs the surveys are investigating. This thread is an event or statement from the teachers' story that you have them reflect on. It is more beneficial to lead the teacher to a place they already are going or want to go with their beliefs than to try and impose other beliefs on them. This is similar to recognizing the even though a child has a flawed strategy, it has the potential of becoming a valid strategy and the teacher wants to continue the child's line of thinking rather than imparting her own strategy on the child. The math stories aid mathematics educators and professional development leaders the ability to individualize the instruction so that the teachers can continue their own line of thinking and not have to assimilate brand new beliefs forced upon them. This will yield better results (Bright & Vacc, 1994), which in turn is better for all children.

Chapter 5: The End of the Story

So comes the end of my story. To quote Charles Dickens, "It was the best of times. It was the worst of times." The process of completing this dissertation was exciting, interesting, traumatic, and life changing. I enjoyed collecting the data and poring over them to find connections to discuss. Each time I read the math stories, I found some nuance that I had overlooked before. The downside to this high was trying to find a way to write down the many thoughts I had in some organized, coherent manner. I could talk about what I observed to anyone, anytime. Transferring my thoughts to paper was difficult to say the least. A dissertation is supposed to add to the research and provide stepping-stones for future research. I feel that enormous responsibility played a role in the negative emotions I felt while writing this paper. In the end, however, I was able to provide findings worthy of a dissertation, and in this final chapter, I will expand on them as well as indicate possible future directions for this research.

GENERAL POSSIBILITIES FOR FUTURE RESEARCH

The math story as an instrument provides insight into the trajectory of teachers' beliefs; therefore, it would be of interest to expand the scope of this study from one snapshot to a longitudinal study, in which each tool is given multiple times over a span of several years. Several interesting topics could be explored. First, how does a math story change over the years? Do the teachers recall different events? If they recall similar events, are they similar to their earlier versions or have there been changes? What kind of changes? Are the same beliefs evident in their stories with the same level of conviction? A second topic to explore is the comparison of their IMAP survey results as time passes. The survey was designed so that beliefs could be compared, so it would function well for this purpose. A third possible topic is to again look at how the surveys support each other. One could track a teacher's story as well as the changes (if any) of their beliefs based on the IMAP survey. Are these changes reflected in their math story? Depending on the researcher's purpose for investigating teachers' beliefs, many aspects could be investigated.

NEED FOR COMPACTNESS OF THE SURVEYS

In order to make the use of these two instruments practical, methods of decreasing the time needed to analyze and draw conclusions are necessary. The manner in which the tools are given to the teachers could be streamlined. A modified version of the math story has been used in elementary methods classrooms (LoPresto & Drake, 2005). Also, only using select questions from the IMAP survey would decrease the time to take the survey and to code the information. Narrowing the focus to only one of the three major categories or even just one belief would allow the researcher to concentrate on a smaller set of data, thus decreasing the time for analysis. The reason for these needs is that if the distribution, completion, and analysis of the instruments and data take a long time, the results cease to be useful in professional development and even in classroom studies. Follow-up questions are possible if more detail is necessary after scaling back the instruments.

CODING MATH STORIES FOR BELIEFS

Further refinement of coding math stories for beliefs could also be pursued. This would allow for an examination of beliefs derived from a narrative, instead of the common investigation of propositional beliefs. Also, other kinds of beliefs related to mathematics could be identified and investigated. The IMAP survey beliefs were chosen because the instrument was a logical choice for the study. This choice does not discount, however, the possibility that other beliefs regarding teaching mathematics could be evident using another instrument.

FINAL THOUGHTS

The more I worked on this study, the more ideas I had about the directions that could be explored in the future. Even just comparing different groups of teachers (e.g. ,novice vs. experienced; elementary vs. secondary; male vs. female) would be of interest and could further detail teachers' beliefs about mathematics and the teaching of mathematics. All it takes is curiosity and a willingness of teachers to want to learn more about themselves and their beliefs. That is what motivated me.

Appendix A: Math Story Protocol

From Drake, C., Spillane, J. P., & Hufferd-Ackles, K. (2001)

I. Introductory Comments

This is an interview about the story of your life experiences with math. Teacher's lives vary tremendously, and they make sense of their own math experiences in a variety of ways. Our goal is to begin the process of making sense of how teachers interpret their own math experiences. Therefore, I am collecting and analyzing the stories of teachers' experiences with math and looking for significant commonalties and significant differences in those stories that people tell us.

II. Critical Events

We would like you to concentrate on a few key events that may stand out in bold print in your story. A key event should be a specific happening, a critical incident, a significant episode in your past set in a particular time and place. It is helpful to think of such an event as constituting a specific moment which stands out for some reason in your experiences with math. A very difficult year in high school would not qualify as a key event because it took place over an extended period of time.

I am going to ask you about several specific events. For each event, describe in as much detail as you can what happened, where you were, who was involved, what you did, and what you were thinking and feeling in the event. Also, try to convey what impact this key event has had in the story of your life experiences with math and what this event says about who you are or were as a person and as a teacher.

Event #1: Peak Experience

A peak experience would be a high point in your story about math in your life—perhaps the high point. It would be a moment or episode in the story in which you experienced extremely positive emotions; like joy, excitement, great happiness, uplifting, or even deep inner peace after some math experience. Tell me exactly what happened, where it happened, who was involved, what you did, what you were thinking and feeling, what impact this experience may have had upon you, and what this experience says about who you were or who you are now as a teacher.

Event #2: Nadir Experience

A "nadir" is a low point. A nadir experience, therefore, is the opposite of a peak experience. It is a low point in your experiences with math. Thinking back over your life, try to remember a specific experience in which you felt extremely negative emotions about math. You should consider this experience to represent one of the "low points" in your math story. What happened? When? Who was involved? What did you do? What were you thinking and feeling? What impact has the event had on you? What does the event say about who you are or who you were as a teacher?

Event #3: Turning Point

In looking back on one's life, it is often possible to identify certain key "turning points"—episodes through which a person undergoes substantial change. I am especially interested in a turning point in your understanding of math. Please identify a particular episode in your life story that you now see as a turning point. If you feel that your math story contains no turning points, then describe a particular episode in your life that comes closer than any other to qualifying as a turning point.

Event #4: Important Childhood Scene

Now describe a memory about math from your childhood that stands out in your mind as especially important or significant. It may be a positive or negative memory. What happened? Who was involved? What did you do? What were you thinking and feeling? What impact has the event had on you? What does it say about who you were? Why is it important?

Event #5: Important Adolescent Scene

Describe a specific event from your adolescent years that stands out as being especially important or significant with respect to math.

Event #6: Important Adult Scene

Describe a specific event from your adult years (age 21 and beyond) that stands out as being especially important or significant with respect to math.

Event #7: One Other Important Scene

Describe one more event, from any point in your life, that stands out in your memory as being especially important or significant with respect to math.

III. Life Challenge

Looking back over your life and interactions with math, please describe the single greatest challenge that you have faced. How have you faced, handled, or dealt with this challenge? Have other people assisted you in dealing with this challenge? How has this challenge had an impact on your experiences with math?

IV. Influences on the Life Story: Positive and Negative

Positive

Looking back over your life story, please identify the single person, group of persons, or organization/institution that has or have had the greatest positive influence on your perspective of math. Please describe this person, group, or organization and the way in which he, she, it or they have had a positive impact on your story.

Negative

Looking back over your life story, please identify the single person, group of persons, or organization/institution that has or have had the greatest negative influence on your perspective of math. Please describe this person, group, or organization and the way in which he, she, it or they have had a negative impact on your story.

V. Alternative Futures for the Life Story

Now that you have told me a little bit about your past, I would like you to consider the future. I would like you to imagine two different futures for your story.

Positive Future

First, please describe a positive future. That is, please describe what you would like to happen in the future with regards to your interactions with math, including what goals and dreams you might accomplish or realize in the future.

Negative Future

Now, please describe a negative future. That is, please describe a highly undesirable future for yourself with regards to your interactions with math, one that you fear could happen to you but that you hope does not happen.

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Vita

Kevin Daniel LoPresto was born in Rochester, NY to Edward and Patricia on June 3, 1967. Upon graduating from Greece Arcadia High School, Kevin attended SUNY Geneseo, where he majored in mathematics and minored in computer science and philosophy. He earned a Bachelor of Arts degree in mathematics in 1989. He then obtained his Masters of Arts degree in mathematics at SUNY Albany in 1990. After earning his master's degree, Kevin received permanent teaching certification in secondary mathematics, 7–12, in New York state. During the next eight years, Kevin taught mathematics at Greece Olympia, Greece Arcadia, and Greece Odyssey schools in Rochester, teaching courses ranging from seventh grade math through AP calculus.

In 1998 Kevin enrolled at the University of Texas at Austin in the science and mathematics doctoral program. While a student at Texas, he taught several sections of elementary math methods for the College of Education, as well as Functions and Modeling, a domain course for the UTeach program. He also taught business calculus and precalculus at Concordia University.

In 2003 Kevin accepted a position as special purposes faculty at Radford University in Radford, VA, where he teaches mathematics education for both the elementary and secondary mathematics programs. He currently resides at 213 River Pointe, Radford, VA, 24141.

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This dissertation was typed by the author and edited by Sonny Regelman and Cynthia Fleming Wood.